SCIENCE

EDITORIAL COMMITTEE: S. NEWCOMB, Mathematics; R. S. WOODWARD, Mechanics; E. C. PICKERING, Astronomy; T. C. MENDENHALL, Physics; R. H. THURSTON, Engineering; IRA REMSEN, Chemistry; JOSEPH LE CONTE, Geology; W. M. DAVIS, Physiography; HENRY F. OSBORN, Paleontology; W. K. BROOKS, C. HART MERRIAM, Zoology; S. H. SCUDDER, Entomology; C. E. BESSEY, N. L. BRITTON, Botany; C. S. MINOT, Embryology, Histology; H. P. BOWDITCH, Physiology; J. S. BILLINGS, Hygiene; WILLIAM H. WELCH, Pathology; J. MCKEEN CATTELL, Psychology; J. W. POWELL, Anthropology.

FRIDAY, SEPTEMBER 28, 1900.

CONTENTS:

The International Catalogue: SIR MICHAEL FOSTER..... 457

Address of the President of the Botanical Section of the British Association: PROFESSOR S. H. VINES. 459

The Method of Types in Botanical Nomenclature: DR. O. F. COOK..... 475

Scientific Books:—

Memoirs in Honor of Sir George Gabriel Stokes, Tait's Scientific Papers, Reynold's Papers on Mechanical and Physical Subjects: R. S. W. *Kohlrausch's Kleiner Leitfaden der praktischen Physik:* PROFESSOR W. HALLOCK. *Education in the United States:* PROFESSOR PAUL H. HANUS. *Hampson's Catalogue of the Lepidoptera Phalænæ in the British Museum:* DR. HARRISON G. DYAR 481

Discussion and Correspondence:—

The Psychology of Pity: HIRAM M. STANLEY. *The Kieffer Pear and the San José Scale:* PROFESSOR T. D. A. COCKERELL..... 487

Notes on Physics:—

Architectural Acoustics: W. S. F..... 489

Notes on Inorganic Chemistry: J. L. H..... 489

Academei dei Lincei of Rome..... 490

The Importation of Living Animals..... 491

Street Cars in Glasgow..... 491

Scientific Notes and News..... 492

University and Educational News..... 496

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson N. Y.

THE INTERNATIONAL CATALOGUE.

AT the end of last month the Smithsonian Institution sent out a circular letter inviting various bodies in America to subscribe for a period of five years to the proposed International Catalogue of Scientific Literature. At an early stage of the deliberations concerning the Catalogue, it became evident that the necessary financial basis for the undertaking could not be secured on the plan of direct contributions from the several countries interested in the matter. An adequate basis however presented itself in the form of guaranteed subscriptions for a certain period; and it was calculated that a guarantee of subscriptions of about 300 complete sets would justify the work being begun. The German government undertook to subscribe for 45 complete sets for five years; other governments undertook subscriptions of lesser amounts; the Royal Society guaranteed that 45 copies should be subscribed for in Great Britain and Ireland; and, at the close of the International Conference, in June last, the financial prospects were found to be such that if subscriptions for 45 complete sets for five years, in the United States of America, could be assured, the work might at once be put in hand. The Smithsonian Institution undertook the task of asking for subscriptions; hence the circular in question.

Visiting Washington on Tuesday, last, I had the extreme gratification of learning that

more than 45 complete sets (or the equivalent) had been already subscribed. The Catalogue, therefore, will be begun at once. Considering that the appeal of the Smithsonian Institution was made under most unfavorable conditions, namely in the middle of the vacation, I cannot but regard the result as a most encouraging proof that America is determined to give its characteristic support to what I think I may venture to call a most important international scientific undertaking. And I can myself all the more fully appreciate the value of this support because I am well aware that several features of the scheme for the conduct of the Catalogue have been severely criticised in this country, in which above all other countries much thought and labor has been spent on the problems of indexing.

May I take the opportunity of expressing on the part of the Royal Society of London a grateful recognition of that support, and at the same time of making, on my own responsibility, a few remarks on the whole subject.

1. Two different plans of indexing scientific literature by international cooperation present themselves. One is that this or that country should undertake the indexing of this or that branch of science, taking in hand the whole literature of that branch, the several countries agreeing among themselves to cover in this way the whole field of science. Another plan is for each country to collect the data of its own literature in all branches of science and for the final collation and editing of all the literature to be conducted in some international central office. Each plan has its advantages and disadvantages. The International Conference adopted the second plan; but this has necessarily had the drawback that it could not provide at once and directly for attaching to its organization undertakings already existing upon the other plan. An alliance of such organizations with its own could only be brought about, if at all, by prolonged and difficult negotiations, however desirable such an alliance might seem.

2. The Catalogue is intended for two classes: for the scientific investigator and for libraries. So far perhaps the chief attention has been directed to the needs of the scientific investigator, as was natural seeing that the most active workers in the undertaking have been men of science engaged in investigation. But I think I am justified in saying that the men of science in question are fully aware of the great importance of making the Catalogue of value to libraries as well as to individual workers in science, and trust that in time it may be made equally useful to both.

3. At the first Conference it was decided that the Catalogue should be in a 'card' form as well as in a book form; but it was subsequently decided to give up the 'card' form *for the present*. This decision was based simply on the complexity of organization and expense which the card issue would involve. It was thought wiser to begin at least with the simpler book issue alone; but it is hoped by some that should the simpler enterprise prove successful, and the machinery be found to be manageable, the issue of cards may at some future day be undertaken.

4. No part of the scheme has met with more severe criticism than the schedules of classifications. With regard to these I venture to say that few persons, save those behind the scenes, can know the amount of labor which has been spent upon them. In the course of my life I have met with various things fertile in disagreements; but for a real apple of discord, nothing that I know of comes near to a schedule of classification; and it is, I imagine, unnecessary to say that the schedules as adopted represent the results of compromises, compromises in

some cases at least come to with much misgiving.

It must be remembered that though some of the schedules in question have been tested (and corrected) by being actually applied to a considerable mass of literature, they will all be severely tested by the actual experience even of the first year.

Speaking now entirely for myself and giving only my own opinion, I cannot expect otherwise than that the experience of the first year (or possibly even a shorter experience) will compel the International Council to authorize changes in the schedules. This, if done, will have the disadvantage of making the second year's Catalogue not wholly homogeneous with the first year's; but this I venture to think will be more than balanced by the better character of the second year's issue. Similarly with the third and fourth years. When the fifth year is reached, the Catalogue if it is to answer the expectations which it has raised may be expected to have passed through at least its main metamorphoses and to have assumed its adult form. If at the end of the fifth year, the office will be able, and it is hoped it will be able, to issue not only the Catalogue for the fifth year, but also a combined catalogue of all the five years taken together, then if that five year Catalogue and the fifth year Catalogue are not fully worth, both to workers and to libraries, the money asked for them, the whole enterprise had better be abandoned. And I would venture to urge very earnestly that the worth of the Catalogue should not be judged by its first issues; they must necessarily be most imperfect; they can only present not the achievement but the promise of what is intended.

5. As a substitute for cards, it was suggested that a bimonthly issue might be adopted, or an issue on an accumulative plan; but the Conference decided in the first instance to be content with the simple annual book issue. There seems, however, to be no reason why special arrangements should not be made by which a subscriber should receive the Catalogue printed on one side only of the paper. Scissors and paste would soon convert this into a card catalogue.

6. The subscriptions asked for by the Smithsonian Institution, namely for complete sets of the 17 volumes a year, for five years, represent part of the financial basis of the enterprise. The calculations made show that an annual sale of about 300 sets of 17 volumes representing 17 branches of science at an *average cost* per volume of £1, *i. e.*, £17 or $85 for a complete set will put the whole undertaking on a sound financial basis. The price of each volume will of course not be the same, some volumes (*e. g.*, Zoology) will be much larger than others (*e. g.*, Mineralogy). The exact price of each volume cannot be determined until the size, *i. e.*, the number of entries in that volume, is approximately known. Hence at present subscriptions for individual volumes at a stated price cannot be invited. Ultimately of course not only each volume, but in certain cases at least, parts of a volume, *i. e.*, indices of subdivisions of a branch of science will be offered for sale. The prices and conditions of sale will be determined hereafter.

M. FOSTER.

GARRISON-ON-HUDSON, N. Y.,
September 21, 1900.

ADDRESS OF THE PRESIDENT OF THE BOTANICAL SECTION OF THE BRITISH ASSOCIATION.

THERE has been considerable difference of opinion as to whether the present year marks the close of the nineteenth or the beginning of the twentieth century. But whatever may be the right or the wrong of this vexed question, the fact that the year-date now begins with '19' instead of with '18' suggests the appropriateness of

devoting an occasion such as the present to a review of the century which has closed, as some will have it, or, in the opinion of others, is about to close. I therefore propose to address you upon the progress of Botany during the nineteenth century.

I am fully conscious of the magnitude of the task which I am undertaking, more especially in its relation to the limits of time and space at my disposal. So eventful has the period been that to give in any detail an account of what has been accomplished during the last hundred years would mean to write the larger half of the entire history of Botany. This being so, it might appear almost hopeless to attempt to deal with so large a subject in a presidential address. But I trust that the very restrictions under which I labor may prove to be rather advantageous than otherwise, inasmuch as they compel me to confine attention to what is of primary importance, and thus to give special prominence to the main lines along which the development of the science has proceeded.

STATISTICS.

We may well begin with what is, after all, the most fundamental matter, viz, the relative numbers of known species of plants at the beginning and at the end of the century. It might appear that the statistics of plants was a subject susceptible of very simple treatment, but unfortunately this is not the case. It must be remembered that a 'species' is not an invariable standard unit, like a pound or a pint, but that it is an idea dependent upon the subjectivity of individual botanists. For instance, one botanist may regard a certain number of similar plants as all belonging to a single species, whilst another may find the differences among them such as to warrant the distinction of as many species as there are plants. It is this inevitable variation in the estimation of specific characters which renders it difficult to deal satisfactorily with plants from the statistical point of view. However, the following figures may be regarded as giving a fair idea of the increase in the number of 'good' species of living plants.

It is generally stated that about 10,000 species of plants were known to Linnæus in the latter half of the eighteenth century, of which about one-tenth were Cryptogams; but so rapid was the progress in the study of new plants at that time that the first enumeration of plants published in the nineteenth century, the 'Synopsis' of Persoon (1807), included as many as 20,000 species of Phanerogams alone. Turning now to the end of the century, we arrive at the following census, for which I am indebted mainly to Professor Saccardo (1892) and to Professor de Toni who has kindly given me special information as to the Algæ:

Species of Phanerogams indicated in Bentham and Hooker's 'Genera Plantarum' (Durand, 'Index,' 1888).

Dicotyledons	78,200
Monocotyledons	19,600
Gymnosperms	2,420
	100,220
Estimated subsequent additions (Saccardo)	5,011
Total Phanerogams	105,231

Species of Pteridophyta (indicated in Hooker and Baker's 'Synopsis'; Baker's 'New Ferns' and 'Fern Allies').

Filicinæ (including Isoëtes), about	3,000
Lycopodinæ, about	432
Equisetinæ, about	20
Total Pteridophyta	3,452

Species of Bryophyta (Saccardo's Estimate).

Musci	4,609
Hepaticæ	3,041
Total Bryophyta	7,650

Species of Thallophyta.

Fungi (including Bacteria) (Saccardo)	39,663
Lichens (Saccardo)	5,600
Algæ (incl. 6000 Diatoms) (de Toni)	14,000
Total Thallophyta	59,263

Adding these totals together—

Phanerogams	105,231
Pteridophyta	3,452
Bryophyta	7,650
Thallophyta	59,263
we have a grand total of	175,596

as the approximate number of recognized species of living plants.

These figures are sufficiently accurate to show how vast have been the additions to the knowledge of plants in the period under consideration, and they afford much food for thought. In the first place, they indicate how closely connected has been the growth of this branch of Botany with the exploration and opening-up of new countries which has been so characteristic a feature of the century. Again, no one can consider these figures without being struck by the disparity in the numbers of species included in the different groups; a most interesting topic, which cannot, however, be entered upon here. It must suffice to point out in a general way that the smaller groups represent families of plants which attained their numerical zenith in long past geological periods, and are now decadent, whilst the existing flora of the world is characterized by the preponderating Angiosperms and Fungi.

We may venture to cast a forward glance upon the possible future development of the knowledge of species. Various partial estimates have been made as to the probable number of existing species of this or that group, but the only comprehensive estimate with which I am acquainted is that of Professor Saccardo (1892). He begins with a somewhat startling calculation to the effect that there are at least 250,000 existing species of Fungi alone, and he goes on to suggest that probably the number of species belonging to the various other groups would amount to 150,000; hence the total number of species now living is to be estimated at over 400,000. On the basis of this estimate it appears that we have not yet made the acquaintance of half the contemporary species; so that there remains plenty of occupation for systematic and descriptive botanists, especially in the department of Fungology. It is also rather alarming, in view of the predatory instincts of so many of the Fungi, to learn that they constitute so decided a majority of the whole vegetable kingdom.

In spite of the great increase in the number of known species, it cannot be said that any essentially new type of plant has been discovered during the century. So far as the bounds of the vegetable kingdom have been extended at all, it has been by the annexation of groups hitherto regarded as within the sphere of influence of the zoologists. The most notable instance of this has occurred in the case of the Bacteria, or Schizomycetes, as Naegeli termed them. These organisms, discovered by Leeuwenhoek 200 years ago, had always been regarded as infusorian animals until, in 1853, Cohn recognized their vegetable nature and their affinity with the Fungi. These plants have acquired special importance, partly on account of the controversy which arose as to their supposed spontaneous generation, but more especially on account of their remarkable zymogenic and pathogenic properties, so that bacteriology has become one of the new sciences of the century.

CLASSIFICATION.

Having gained some idea of the number of species which have been recognized and described during the century, the next point for consideration is the progress made in the attempt to reduce this mass of material to such order that it can be intelligently apprehended; in a word, to convert a mass of facts into a science; 'Filum ariadneum Botanices est systema, sine quo chaos est Res Herbaria' (Linnæus).

The classification of plants is a problem

which has engaged attention from the very earliest times. Without attempting to enter into the history of the matter, I may just point out that, speaking generally, all the earlier systems of classification were more or less artificial, the subdivisions being based upon the distinctive features of one set of members of the plant. When I say that of all these systems that proposed by Linnæus (1735) was the most purely artificial, I do not imply any reproach: if it was the most artificial, it was at the same time the most serviceable, and its author was fully aware of its artificiality. This system is generally regarded as his most remarkable achievement; but the really great service which Linnæus rendered to science was the clear distinction which he for the first time drew between systems which are artificial and those which are natural. Recognizing, as he did, his inability to frame at that period a satisfactory natural system, he also realized that with the increasing number of known plants some more ready means of determining them was an absolute necessity, and it was for this purpose that he devised his artificial system, not as an end, but as a means. The end to be kept in view was the natural classification: 'Methodus naturalis est ultimus finis Botanices' is his clearly expressed position in the 'Philosophia Botanica.'

There is a certain irony in the fact that the enthusiastic acceptance accorded to his artificial system throughout the greater part of Europe contributed to postpone the realization of Linnæus's cherished hopes with regard to the attainment of a natural classification. It was just in those countries, such as Germany and England, where the Linnean system was most readily adopted that the development of the natural system proceeded most slowly. It was in France, where the Linnean system never secured a firm hold, that the quest of the natural system was pursued; and it is to French botanists more particularly that our present classification is due. It may be traced from its first beginnings with Magnol in 1689, through the bolder attempts of Adanson and of Bernard de Jussieu (1759), to the relatively complete method propounded by Antoine Laurent de Jussieu in his 'Genera Plantarum,' just 100 years later.

The nineteenth century opened with the struggle for predominance between the Jussiean and the Linnean systems. In England the former soon obtained considerable support, notably that of Robert Brown, whose 'Prodromus Floræ Novæ Hollandiæ,' published in 1810, seems to have been the first English botanical work in which the natural system was adopted; but it did not come into general use until it had been popularized by Lindley in the thirties.

Meantime the Jussiean system had been extended and improved by Auguste Pyrame de Candolle (1813–24). It is essentially the Candollean classification which is now most generally in use, and it has been immortalized by its adoption in Bentham and Hooker's 'Genera Plantarum,' one of the great botanical monuments of the century. In Germany, however, it has been widely departed from, the system there in vogue being based upon Brongniart's modification (1828, 1850) of de Candolle's method as elaborated successively by Alex Braun (1864), Eichler (1876–83), and Professor Engler (1886, 1898). It must be admitted that for the last fifty years the further evolution of the natural system, at any rate so far as Phanerogams are concerned, has been confined to Germany.

One of the more important advances in the classification of Phanerogams was based upon Robert Brown's discovery in 1827 of the gymnospermous nature of the ovule in Conifers and Cycads, which led Brongniart (1828) to distinguish these plants as 'Phan-

érogames gymnospermes'; and although the systematic position of these plants has since then been the subject of much discussion, the recognition of the Gymnospermæ as a distinct group of archaic Phanerogams is now definitely accepted.

Moreover, the greatly increased knowledge of the Cryptogams has involved a considerable reconstruction in the classification of that great sub-kingdom. One of the most striking discoveries is that first definitely announced by Schwendener (1869) concerning Lichens, to the effect that the body of a Lichen consists of two distinct organisms, an Alga and a Fungus, living in symbiosis; a discovery which was so nearly made by other contemporary botanists, such as de Bary, Berkeley, and Sachs, and which can be traced back to Haller and Gleditsch in the eighteenth century.

But the discoveries which most affected the classification of the Cryptogams are those relating to their reproduction. Whilst it had been recognized, almost from time immemorial, that Phanerogams reproduce sexually, sexuality was denied to Cryptogams until the observations on Liverworts and Mosses by Schmidel and by Hedwig (of whom it was said that he was born to banish Cryptogamy) in the eighteenth century; and even as late as 1828 we find Brongniart classifying the Fungi and Algæ together as 'Agames.' But in the middle third of the nineteenth century, by the labors of such men as Thuret, Pringsheim, Cohn, Hofmeister, Naegeli, and de Bary, the sexuality of all classes of Cryptograms was clearly established. It is worthy of note that, although the sexuality of the Phanerogams had been accepted for centuries, yet the details of sexual reproduction were first investigated in Cryptogams. For it was not until 1823 that Amici discovered the pollen-tube, and it was more than twenty years later (1846) before he completed his discovery by ascertaining the true significance of the pollen-tube in relation to the development of the embryo; whilst it remained for Strasburger to observe, thirty years later, the actual process of fertilization.

The discovery of the reproductive processes in Cryptogams not only facilitated a natural classification of them, but had the further very important effect of throwing light upon their relation to Phanerogams. Perhaps the most striking botanical achievement of the nineteenth century has been the demonstration by Hofmeister's unrivaled researches (1851) that Phanerogams and Cryptogams are not separated, as was formerly held, by an impassable gulf, but that the higher Cryptogams and the lower Phanerogams are connected by many common features.

The development of the natural classification, of which an account has now been given, proceeded for the most part on the assumption of the immutability of species. As Linnæus expressed it in his 'Fundamenta Botanica,' 'species tot numeramus, quot diversæ formæ in principio sunt creatæ.' It is difficult to understand how, with the point of view, the idea of affinity between species could have arisen at all; and yet the establishment of genera and the attempts at a natural system prove that the idea was operative. The nature of the prevalent conception of affinity is well conveyed by Linnæus's aphorism, 'Affines conveniunt habitu, nascendi modo, proprietatibus, veribus, usu.'

But a conviction had been gradually growing that the assumed fixity of species was not well founded, and that, on the contrary, species are descended from preexistent species. This view found clear expression in Lamarck's 'Philosophie zoologique,' published early in the century (1809), but it did not strongly affect public opinion until after the publication of Darwin's 'Origin of Species' in 1859. Regarded from this point of view the problems of

classification have assumed an altogether different aspect. Affinity no longer means mere similarity, but blood-relationship depending upon common descent. We no longer seek a 'system' of classification; we endeavor to determine the mutual relations of plants. The effect of this change has been to stimulate the investigation of plants in all their parts and in all stages of their life, so as to attain that complete knowledge of them without which their affinities cannot be accurately estimated. If the classification of Cryptogams is, at the present monent, in a more satisfactory position than that of Phanerogams, it is just because the study of the former group has been, for various reasons, more thorough and more minute than that of the latter.

PALEOPHYTOLOGY.

The stimulating influence of the new doctrine was not, however, confined to the investigation of existing plants; it also gave a remarkable impulse to the study of fossil plants, inasmuch as the theory of descent involves the quest of the ancestors of the forms that we now have around us. Marvelous progress has been made in this direction during the nineteenth century, by the labors more especially of Brongniart, Goeppert, Unger, Schimper, Schenck, Saporta, Solms-Laubach, Renault, on the Continent, and in our own country of Lindley and Hutton, Hooker, Carruthers, and more especially of Williamson. So far-reaching are the results obtained that I can only attempt the barest summary of them. I may perhaps best begin by saying that only a small proportion of existing species have been found in the fossil state. In illustration I may adduce the statement made by Mr. Clement Reid in his recent work, 'The Origin of the British Flora,' that only 270 species that is, about one-sixth of the total number of British vascular plants, are known as fossils. Making all due allowances for the imperfection of the geological record, for the limited area investigated, and for the difficulty of determination of fragmentary specimens, it may be stated generally that the number of existing species has been found to rapidly diminish in the floras of successively older strata; none, in fact, has been certainly found to persist beyond the Tertiary period. Certain existing genera, belonging to the Gymnosperms and to the Pteridophyta, have, however, been traced far down into the Mesozoic period. Similarly, the distribution in time of existing natural orders does not coincide with that of existing genera; thus the Ferns of the Carboniferous epoch apparently belong, for the most part, if not altogether, to the order Marattiaceæ, but they are not referable to any of the existing genera.

Moreover, altogether new families of fossil plants have been discovered: such are, among Gymnosperms, the Cordaitaceæ and the Bennettitaceæ; among Pteridophyta, the Calamariaceæ, the Lepidodendraceæ, the Sphenophyllaceæ and the Cycadofilices. It is of interest to note that all these newly discovered families can be included within the main subdivisions of the existing flora; in fact, no fossil plants have been found which suggest the existence in the past of groups outside the limits of our Phanerogamia, Pteridophyta, Bryophyta and Thallophyta.

It cannot be said that the study of Paleobotany has as yet made clear the ancestry and the descent of our existing flora. To begin with the angiospermous flowering plants, it has been ascertained that they make their first appearance in the Cretaceous epoch, but we have no clue as to their origin. The relatively late appearance of Angiosperms in geological time suggests that they must have sprung from an older group, such as the Gymnosperms or the Pteridophyta; but there is no evidence to

definitely establish either of these possible origins. Then as to the origin of the Gymnosperms, whilst it cannot be doubted that they were derived from the Pteridophyta, the existing data are insufficient to enable us to trace their pedigree. The most ancient family of Gymnosperms, the Cordaitaceæ, can be traced as far back as any known Pteridophyta, and cannot, therefore, have been derived from them; but the fact that the Cordaitaceæ exhibit certain cycadean affinities, and the discovery of the Cycadofilices, suggest that what may be termed the cycadean phylum of Gymnosperms (including the Cordaitaceæ, Bennettitaceæ, Cycadaceæ, and perhaps the Ginkgoaceæ) had its origin in a filicineous ancestry, of which, it must be admitted, no forms have as yet been recognized.

Turning to the Pteridophyta, the origin of the Ferns is still quite unknown: the one fact which seems to be clear is that the eusporangiate forms (Marattiaceæ) are more primitive than the leptosporangiate. With regard to the Equisetinæ, the Calamariaceæ were no doubt the ancestors of the existing and of the fossil Equisetums. Similarly, in the Lycopodinæ, the paleozoic Lepidodendraceæ were the forerunners of the existing Lycopodiums and Selaginellas. The discovery of the Sphenophyllaceæ seems to throw some further light upon the phylogeny of these two groups, inasmuch as these plants possess characters which indicate affinity with both the Equisetinæ and the Lycopodinæ, thus suggesting the possibility that they may have sprung from the same ancestral stock.

To complete the geological survey of the vegetable kingdom I will briefly allude to the Bryophyta and the Thallophyta. Owing no doubt to their delicate texture, the records of these plants have been found to be very incomplete. So much is this the case with the Bryophyta that I forbear to make any statement concerning them. The chief point of interest with regard to the Fungi is that most of those which have been discovered in the fossil state were found in the tissues of woody plants on which they were parasitic. In this way it has been possible to ascertain, with some probability, the existence of Bacteria and of mycelial Fungi in the Paleozoic period. The records of the Algæ are more satisfactory; they have been traced far back into the Paleozoic age, where they are represented by siphonaceous forms and by the somewhat obscure plants known as *Nematophycus* and *Pachytheca*.

In a general way the study of Paleobotany has proved the development of higher from lower forms in the successive geological periods. Thus the Tertiary and Quaternary periods are characterized by the predominance of Angiosperms, just as the Mesozoic period is characterized by the predominance of Gymnosperms, and the Paleozoic by the predominance of Pteridophyta. And yet, as I have been pointing out, we are not able to trace the ancestry of any one of the larger groups of plants. The chief reason for this is that the geological record, so far as it is known, has been found to break off with such surprising abruptness that the earliest, and, therefore, the most interesting, chapters in the evolution of plants are closed to us. After the wealth of plant-forms in the Carboniferous epoch there is a striking falling-off in the Devonian, in which, however, plants of high organization, such as the Cordaitaceæ, the Calamariaceæ and the Lepidodendraceæ, still occur. In the Silurian epoch vascular plants are but sparingly present—but it is remarkable that any such highly organized plants should be found there—together with probable Algæ, such as *Nematophycus* and *Pachytheca*. The Cambrian rocks present nothing but so-called 'Fucoids,' such as *Eophyton*, etc., some of which may be Algæ. The only known fos-

sil in the oldest strata of all, the Archæan, is the much-discussed *Eozoon canadense*, probably of animal origin; but the occurrence here of large deposits of graphite seems to indicate the existence of a considerable flora which has, unfortunately, become quite undeterminable. Thus, whilst there is some evidence that the primitive plants were Algæ, there is at present no available record of the various stages through which the Silurian and Devonian vascular plants were evolved from them.

MORPHOLOGY.

If inquiry be made as to the cause of the great advance in the recognition of the true affinities of plants, and consequently in their classification, which distinguishes the nineteenth century, I would refer it to the progress made in the study of morphology. The earlier botanists regarded all the various parts of plants as 'organs' in relation to their supposed function; hence their description of plants was simply 'organography.' The idea of regarding the parts of the plant-body, not in connection with their functions, but with reference to their development and their mutual relations, seems to have originated with Jung in the seventeenth century (1687): it was revived by C. F. Wolff about seventy years later (1759), but it did not materially affect the study of plants until well on in the nineteenth century, after Goethe had repeatedly written on the subject and had devised the term 'morphology' to designate it. For a time this somewhat abstract mode of treatment led to mere theorizing and speculation, so much so that the years 1820–1840 will always be stigmatized as the period of the 'Naturphilosophie.' But fortunately this time of barrenness was succeeded by a veritable renascence. Robert Brown and Henfrey in England; Brongniart, St. Hilaire, and Tulasne in France; Mohl, Schleiden, Naegeli, A. Braun and above all Hofmeister in Germany, led the way back from the pursuit of fantastic will-o'-the-wisps to the observation of actual fact. Instead of evolving schemes out of their own internal consciousness as to how plants ought to be constructed, they endeavored to discover by the study of development, and more particularly of embryogeny, how they actually are constructed, with the result that within a decade Hofmeister discovered the alternation of generations in the higher plants; a discovery which must ever rank as one of the most brilliant triumphs of morphological research.

With the knowledge thus acquired it became possible to determine the true relations of the various parts of the plant-body; to distinguish these parts as 'members' rather than as 'organs'; in a word, to establish homologies where hitherto only analogies had been traced—which is the essential difference between morphology and organography.

The publication of the 'Origin of Species' profoundly affected the progress of morphology, as of all branches of biological research; but it did not alter its trend; it confirmed and extended it. We are not satisfied now with establishing homologies, but we go on to inquire into the origin and phylogeny of the members of the body. In illustration I may briefly refer to two problems of this kind which at the present time are agitating the botanical world. The first is as to the origin of the alternation of generations. Did it come about by the modification of the sexual generation (gametophyte) into an asexual (sporophyte); or is the sporophyte a new formation intercalated into the life-history? In a word, is the alternation of generations to be regarded as homologous or as antithetic? I am not rash enough to express any opinion on this controversy; nor is it necessary that I should do so, since the subject has twice

been threshed out at recent meetings of this Section. The second problem is as to the origin of the sporophylls, and, indeed, of all the various kinds of leaves of the sporophyte in the higher plants. It is suggested, on the one hand, that the sporophylls of the Pteridophyta have arisen by gradual sterilization and segmentation from an unsegmented and almost wholly reproductive body, represented in our day by the sporogonium of the Bryophyta; and that the vegetative leaves have been derived by further sterilization from the sporophylls. On the other hand, it is urged that the vegetative leaves are the more primitive, and that the sporophylls have been derived from them. It will be at once observed that this second problem is intimately connected with the first. The sterilization theory of the origin of leaves is a necessary consequence of the antithetic view of the alternation of generations; whilst the derivation of sporophylls from foliage-leaves is similarly associated with the homologous view. Here, again, exercising a wise discretion, I will only venture to express my appreciation of the important work which has been done in connection with this controversy—work that will be equally valuable, whatever the issue may eventually be.

I will conclude my remarks on morphology with a few illustrations of the aid which the advance in this department has given to the progress of classification. For instance, Linnæus divided plants into Phanerogams and Cryptogams, on the ground that in the former the reproductive organs and processes are conspicuous, whereas in the latter they are obscure. In view of our increased knowledge of Cryptogams, this ground of distinction is no longer tenable; whilst still recognizing the validity of the division, our reasons for doing so are altogether different. For us, Phanerogams are plants which produce a seed; Cryptogams are plants which do not produce a seed. Again, we distinguish the Pteridophyta and the Bryophyta from the Thallophyta, not on account of their more complex structure, but mainly on the ground that the alternation of generations is regular in the two former groups, whilst it is irregular or altogether wanting in the latter. Similarly the essential distinction between the Pteridophyta and the Bryophyta is that in the former the sporophyte, in the latter the gametophyte, is the preponderating form. It has enabled us further to correct in many respects the classifications of our predecessors by altering the systematic position of various genera, and sometimes of larger groups. Thus the Cycadaceæ have been removed from among the Monocotyledons, and the Coniferæ from among the Dicotyledons, where de Candolle placed them, and have been united with the Gnetaceæ into the sub-class Gymnospermæ. The investigation of the development of the flower, in which Payer led the way, and the elaboration of the floral diagram which we owe to Eichler, have done much, though by no means all, to determine the affinities of doubtful Angiosperms, especially among those previously relegated to the lumber-room of the Apetalæ.

ANATOMY AND HISTOLOGY.

Passing now to the consideration of the progress of knowledge concerning the structure of plants, the most important result to be chronicled is the discovery that the plant-body consists of living substance indistinguishable from that of which the body of animals is composed. The earlier anatomists, whilst recognizing the cellular structure of plants, had confined their attention to the examination of the cell-walls, and described the contents as a watery or mucilaginous sap, without determining where or what was the seat of life. In 1831 Robert Brown discovered the nucleus of

the cell, but there is no evidence that he regarded it as living. It was not until the renascence of research in the forties, to which I have already alluded, that any real progress in this direction was made. The cell-contents were especially studied by Naegeli and by Mohl, both of whom recognized the existence of a viscous substance lining the wall of all living cells as a 'mucous layer' or 'primordial utricle,' but differing chemically from the substance of the wall by being nitrogenous: this they regarded as the living part of cell, and to it Mohl (1846) gave the name 'protoplasm,' which it still bears. The full significance of this discovery became apparent in a somewhat roundabout way. Dujardin, in 1835, had described a number of lowly organisms, which he termed Infusoria, as consisting of a living substance, which he called 'sarcode.' Fifteen years later, in a remarkable paper on *Protococcus pluvialis*, Cohn drew attention to the similarity in properties between the 'sarcode' of the Infusoria and the living substance of this plant, and arrived at the brilliant generalization that the 'protoplasm' of the botanists and the 'sarcode' of the zoologists are identical. Thus arose the great conception of the essential unity of life in all living things, which, thanks to the subsequent labors of such men as de Bary, Brücke, and Max Schultze, in the first instance, has become a fundamental canon of Biology.

A conspicuous monument of this period of activity is the cell-theory propounded by Schwann in 1839. Briefly stated, Schwann's theory was that all living bodies are built up of structural units which are the cells: each cell possesses an independent vitality, so that nutrition and growth are referable, not to the organism as a whole, but to the individual cells. This conception of the structure of plants was accepted for many years, but it has had to give way before the advance of anatomical knowledge. The recognition of cell-division as the process by which the cells are multiplied—in opposition to the Schleidenian theory of free cell-formation—early suggested doubts as to the propriety of regarding the body as being built up of cells as a wall is built of bricks. Later the minute study of the Thallophyta revealed the existence of a number of plants, such as Myxomycetes, the phycomycetous Fungi, and the siphonaceous Algæ, some of them highly organized, the vegetative body of which does not consist of cells. It became clear that cellular structure is not essential to life; that it may be altogether absent or present in various degree. Thus in the higher plants the protoplasm is segmented or septated by walls into uninucleate units or 'energids' (Sachs), and such plants are well described as 'completely septate.' But in others, such as the higher Fungi and certain Algæ (*e. g.*, *Cladophora*, *Hydrodictyon*), the protoplasm is septated, not into energids, but into groups of energids, so that the body is 'incompletely septate.' Finally there are the Thallophyta already enumerated, in which there is complete continuity of the protoplasm: these are 'unseptate.' Moreover, even when the body presents the most complete cellular structure, the energids are not isolated, but are connected by delicate protoplasmic fibrils traversing the intervening walls; a fact which is one of the most striking discoveries in the department of histology. This was first recognized in the sieve-tubes by Hartig (1837); then by Naegeli (1846) in the tissues of the Florideæ. After a long period of neglect the matter was taken up once more by Tangi (1880), when it attracted the attention of many investigators, as the result of whose labors, especially those of Mr. Gardiner, the general and perhaps universal continuity of the protoplasm in cellular plants has been established. Hence the body is no longer regarded as

an aggregate of cells, but as a more or less septated mass of protoplasm: the synthetic standpoint of Schwann has been replaced by one as distinctively analytic.

Time does not permit me to do more than mention the important discoveries made of late years, mainly on the initiative of Strasburger, with regard to the details of cytology, and especially to the structure of the nucleus and the intricate dance of the chromosomes in karyokinesis. Indeed, I can do but scant justice to those anatomical discoveries which are of more exclusively botanical interest. One important generalization which may be drawn is that the histological differentiation of the plant proceeds, not in the protoplasm, as in the animal, but in the cell-wall. It is remarkable, on the one hand, how similar the protoplasm is, not only in different parts of the same body, but in plants of widely different affinities; and, on the other, what diversity the cell-wall offers in thickness, chemical composition, and physical properties. In studying the differentiation of the cell-wall the botanist has received valuable aid from the chemist. Research in this direction may, in fact, be said to have begun with Payen's fundamental discovery (1844) that the characteristic and primary chemical constituent of the cell-wall is the carbohydrate which he termed cellulose.

The amount of detailed knowledge as to the anatomy of plants which has been accumulated during the century by countless workers, among whom Mohl, Naegeli, Unger, and Sanio deserve special mention as pioneers, is very great—so great, indeed, that it seemed as if it must remain a mere mass of facts in the absence of any recognizable general principles which might serve to marshal the facts into a science. The first step towards a morphology of the tissues was Hanstein's investigation of the growing point of the Phanerogams (1868), and his recognition therein of the three embryonic tissue-systems. This has lately been further developed by the promulgation of van Tieghem's theory of the stele, which is merely the logical outcome of Hanstein's distinction of the plerome. It has thus become possible to determine the homologies of the tissue-systems in different plants and to organize the facts of structure into a scientific comparative anatomy. It has become apparent that, in many cases, differences of structure are immediately traceable to the influence of the environment; in fact, the study of physiological or adaptive anatomy is now a large and important branch of the subject.

The study of Anatomy has contributed in some degree to the progress of systematic Botany. It is true that some of the more ambitious attempts to base classification on Anatomy have not been successful; such, for instance, as de Candolle's subdivision of Phanerogams into Exogens and Endogens, or the subdivision of Cormophyta into Acrobrya, Amphibrya, and Acramphibrya, proposed by Unger and Endlicher. Still it cannot be denied that anatomical characters have been found useful, if not absolutely conclusive, in suggesting affinities, especially in the determination of fossil remains. A large proportion of our knowledge of extinct plants, to which I have already alluded, is based solely upon the anatomical structure of the vegetative organs; and although affinities inferred from such evidence cannot be regarded as final, they suffice for a provisional classification until they are confirmed or disproved by the discovery and investigation of the reproductive organs.

PHYSIOLOGY.

The last branch of the botanical science which I propose to pass in review is that of physiology. We may well begin with the nutritive processes. At the close of the eighteenth century there was practically no

coherent theory of nutrition; such as it was it amounted to little more than the conclusion arrived at by van Helmont a century and a half earlier, that plants require only water for their food, and are able to form from it all the different constituents of their bodies. It is true that the important discovery had been made and pursued by Priestley (1772), Ingen-Housz (1780), and Sénébier (1782) that green plants exposed to light absorb carbon dioxide and evolve free oxygen; but this gaseous interchange had not been shown to be the expression of a nutritive process. At the opening of the nineteenth century (1804) this connection was established by de Saussure, in his classical 'Recherches chimiques,' who demonstrated that, whilst absorbing carbon dioxide and evolving oxygen, green plants gain in dry weight; and he further contributed to the elucidation of the problem of nutrition by showing that, whilst assimilating carbon dioxide, green plants also assimilate the hydrogen and oxygen of water.

Three questions naturally arose in connection with de Saussure's statement of the case: What is the nature of the organic substance formed? What is the function of the chlorophyll? What is the part played by light? It was far on in the century before answers were forthcoming.

With regard to the first of these questions, the researches of Boussingault (1864) and others established the fact that the volume of carbon dioxide absorbed and that of oxygen evolved in connection with the process are approximately equal. Further, the frequent presence of starch in the chloroplastids, to which Mohl first drew attention (1837), was subsequently found by Sachs (1862) to be closely connected with the assimilation of carbon dioxide. The conclusion drawn from these facts is that the gain in dry weight accompanying the assimilation of carbon dioxide is due to the formation, in the first instance, of organic substance having the composition of a carbohydrate; a conclusion which may be expressed by the equation:

$$CO_2 + H_2O = CH_2O + O_2.$$

The questions with regard to chlorophyll and to light are so intimately connected that they must be considered together. The first step towards their solution was the investigation of the relative activity of light of different colors, originally undertaken by Sénébier (1782) and subsequently repeated by Daubeny (1836), with the result that red and orange light was found to promote assimilation in a higher degree than blue or violet light. Shortly afterwards Draper (1843), experimenting with an actual solar spectrum, concluded that the most active rays are the orange and yellow; a conclusion which was generally accepted for many years. But in the meantime the properties of the green coloring matter of plants (to which Pelletier and Caventou gave the name 'chlorophyll' in 1817) were being investigated. Brewster discovered in 1834 that an alcoholic extract of green leaves presents a characteristic absorption spectrum; but many years elapsed before any attempt was made to connect this property with the physiological activity of chlorophyll. It was not until 1871–72 that Lommel and N. J. C. Müller pointed out that the rays of the spectrum which are most completely absorbed by chlorophyll are just those which are most efficient in the assimilation of carbon dioxide. Subsequent researches, particularly those of Timiriazeff (1877), and those of Engelmann (1882–84) based on his ingenious Bacterium-method, have confirmed the views of Lommel and of Müller, and have placed it beyond doubt that the importance of light in the assimilatory process is that it is the form of kinetic energy necessary to effect the chemical changes, and that the function

of chlorophyll is to serve as the means of absorbing this energy and of making it available for the plant.

These are perhaps the most striking discoveries in relation to the nutrition of plants, but there are others of not less importance to which brief allusion must be made. We owe to de Saussure (1804) the first clear demonstration of the fact that plants derive an important part of their food from the soil; but the relative nutritive value of the inorganic salts absorbed in solution was not ascertained until Sachs (1858) reintroduced the method of water-culture which had originated centuries before with Woodward (1699) and had been practiced by Duhamel (1768) and de Saussure. Special interest centers around the question of the nitrogenous nutrition of plants. It was long held, chiefly on the authority of Priestley and of Ingen-Housz, and in spite of the contrary opinion expressed by Sénébier, Woodhouse (1803), and de Saussure, that plants absorb the free nitrogen of the atmosphere by their leaves. This view was not finally abandoned until 1860, when the researches of Boussingault and of Lawes and Gilbert deprived it of all foundation. Since then we have learned that the free nitrogen of the air can be made available for nutrition—not indeed directly by green plants themselves, but, as Berthelot and Winogradsky more especially have shown, by Bacteria in the soil, or, as apparently in the Leguminosæ, by Bacteria actually enclosed in the roots of the plants with which they live symbiotically.

We turn now from the nutritive or anabolic processes to those which are catabolic. The discovery of the latter, just as of the former, was arrived at by the investigation of the gaseous interchange between the plant and the atmosphere. In the eighteenth century Scheele and Priestley had found that, under certain circumstances, plants deteriorate the quality of air; but it is to Ingen-Housz that we owe the discovery that plants, like animals, respire, taking in oxygen and giving off carbon dioxide. And when Sénébier (1800) had ascertained for the inflorescence of *Arum maculatum*, and later de Saussure (1822) for other flowers, that active respiration is associated with an evolution of heat, the connection between respiration and catabolism was established for plants as it had been long before by Lavoisier (1777) in the case of animals.

Among the catabolic processes which have been investigated none are of greater importance than those that are designated by the general term *fermentations*. The first of these to be discovered was the alcoholic fermentation of sugar. Towards the end of the seventeenth century Leeuwenhoek had detected minute globules in fermenting wort; and a century later Lavoisier had ascertained that the chemical process consists in the decomposition of sugar into alcohol and carbon dioxide; but it was not until 1837–38 that, almost simultaneously, Cagniard de Lateur, Schwann, and Kützing discovered that Leeuwenhoek's globules were living organisms, and were the cause of the fermentation. Shortly before, in 1833, Payen and Persoz extracted from malt a substance named *diastase*, which they found could convert the starch of the grain into sugar. These two classes of bodies, causing fermentative changes, were distinguished respectively as *organized* and *unorganized* ferments. The number of the former was rapidly added to by the investigation more especially of the Bacteria, in which Pasteur led the way. The extension of our knowledge of the unorganized ferments, or enzymes, has been even more remarkable: we now know that very many of the metabolic processes are effected by various enzymes, such as those which convert the more complex carbohydrates into others of simpler constitution (diastase, cytase, glucase, inulase, invertase); those

which decompose glucosides (emulsin, myrosin, etc.); those which act on proteids (trypsins) and on fats (lipases); the oxidases, which cause the oxidation of various organic substances; and the zymase, recently extracted from yeast, which causes alcoholic fermentation.

The old distinction of the microorganisms as 'organized ferments' is no longer tenable; for, on the one hand, certain of the chemical changes which they effect can be traced to extractable enzymes which they produce; and, on the other, as Pasteur has asserted, every living cell may become an 'organized ferment' under appropriate conditions. The distinction now to be drawn is between those processes which are due to enzymes and those directly effected by living protoplasm. Many now definitely included in the former class were, until lately, regarded as belonging to the latter; and no doubt future investigation will still further increase the number of the former at the expense of the latter.

The consideration of the metabolic processes leads naturally to that of the function of transpiration and of the means by which water and substances in solution are distributed in the plant. This is perhaps the department of physiology in which progress during the nineteenth century has been least marked. We have got rid, it is true, of the old idea of an ascending crude sap and of a descending elaborated sap, but there have been no fundamental discoveries. With regard to transpiration itself, we know more of the detail of the process, but that is all that can be said. As for root-pressure, Hofmeister (1858–82) discovered that 'bleeding'—as the phenomena of root-pressure were termed by the earlier writers—is not confined, as had hitherto been thought, to trees and shrubs; but the current theory of the process, allowing for the discovery of protoplasm and of osmosis, has advanced but little upon that given by Grew in the third book of his 'Anatomy of Plants' (1675). Again, the mechanism of the transpiration-current in lofty trees remains an unsolved problem. To begin with, there is still some doubt as to the exact channel in which the current travels. Knight (1801–8) first proved that the current travels in the alburnum of the trunk, but not, he thought, in the vessels, for he found them to be dry in the summer, when transpiration is most active; a view in which Dutrochet (1837) subsequently concurred. Meyen (1838) then suggested that the water must travel, not in the lumina, but in the substance of the cells of the vessels, and was supported by such eminent physiologists as Hofmeister (1858), Unger (1864, 1868), and Sachs (1878); but it has since been strongly asserted by Boehm, Elfving, Vesque, Hartig, and Strasburger that the young vessels always contain water, and that the current travels in the lumina and not in the walls of the vessels.

Now as to the force by which the water of the transpiration-current is raised from the roots to the topmost leaf of a lofty tree. From the point of view that the water travels in the substance of the walls, the necessary force need not be great, and would be amply provided by the transpiration of the leaves, inasmuch as the weight of the water raised would be supported by the force of imbibition of the walls. From the point of view that the water travels in the lumina, the force required to raise and support such long columns of water must be considerable. Dismissing at once as quite inadequate such purely physical theories as those of capillarity and gas-pressure, there remain two theories as to the nature of this force which resemble each other in being essentially vitalistic, but differ in that the one involves pressure from below, and the other suction from above. In the one, suggested by Godlewski and by Westermaier (1884), the cells of the medullary rays and

of the wood-parenchyma are supposed to absorb liquid from the vascular tissue at one level and force it back again by a vital act at a higher level: this theory was disposed of by the fact that the transpiration-current can be maintained through a considerable length of a stem killed by heat or by poison. In the other, suggested by Dixon and Joly (1895–99), and also by Askenasy (1895–96), it is assumed that there are, in the trunk of a transpiring tree, continuous columns of water which are in a state of tensile stress, the tension being set up by the vital transpiratory activity of the leaves. Some idea of the enormous tension thus assumed is given by the following simple calculation relating to a tree 120 feet high. Not only has the liquid to be raised to this height, but in its passage upwards a resistance calculated to be equal to about five times the height of the tree has to be overcome. Hence the transpiration-force in such a tree must at least equal the weight of a column of water 720 feet in height; that is, a pressure of about twenty-four atmospheres, or 360 lbs. to the square inch. But there is no evidence to prove that a tension of anything like twenty atmospheres exists, as a matter of fact, in a transpiring tree; on the contrary, such observations as exist (*e. g.*, those of Hales and Boehm) indicate much lower tensions. Under these circumstances we must regretfully confess that yet one more century has closed without bringing the solution of the secular problem of the ascent of the sap.

The nineteenth century has been, fortunately, more fertile in discovery concerning the movements and irritability of plants. But it is surprising how much knowledge on these points had been accumulated by the beginning of the century: the facts of plant-movement, such as the curvatures due to the action of light, the sleep-movements of leaves and flowers, the contact-movements of the leaves of the sensitives, were all familiar. The nineteenth century opened, then, with a considerable store of facts; but what was lacking was an interpretation of them; and whilst it has largely added to the store, its most important work has been done in the direction of explanation.

The first event of importance was the discovery by Knight, in 1806, of the fact that the stems and roots of plants are irritable to the action of gravity and respond to it by assuming definite directions of growth. Many years later the term 'geotropism' was introduced by Frank (1868) to designate the phenomena of growth as affected by gravity, and at the same time Frank announced the important discovery that dorsiventral members, such as leaves, behave quite differently from radial members, such as stems and roots, in that they are diageotropic.

It was a long time before the irritability of plants to the action of light was recognized. Chiefly on the authority of de Candolle (to whom we owe the term 'heliotropism'), heliotropic curvature was accounted for by assuming that the one side received less light than the other, and therefore grew the more rapidly. But the researches of Sachs (1873) and Müller-Thurgau (1876) have made it clear that the direction of the incident rays is the important point, and that a radial stem, obliquely illuminated, is stimulated to curve until its long axis coincides with the incident rays. Moreover, the discovery by Knight (1812) of negative heliotropism in the tendrils of *Vitis* and *Ampelopsis* really put the Candollean theory quite out of court; and further evidence that heliotropic movements are a response to the stimulus of the incident rays of light is afforded by Frank's discovery of the diaheliotropism of dorsiventral members.

The question of the localization of irritability has received a good deal of attention. The fact that the under surface of the pul-

vinus of *Mimosa pudica* is alone sensitive to contact was ascertained by Burnett and Mayo in 1827; and shortly after (1834) Curtis discovered the sensitiveness of the hairs on the upper surface of the leaf of *Dionæa*. After a long period of neglect the subject was taken up by Darwin. The irritability of tendrils to contact had been discovered by Mohl in 1827; but it was Darwin who ascertained, in 1865, that it is confined to the concavity near the tip. In 1875 Darwin found that the irritability of the tentacles of *Drosera* is localized in the terminal gland; and followed this up, in 1880, by asserting that the sensitiveness of the root is localized in the tip, which acts like a brain. This assertion led to a great deal of controversy, but the researches of Pfeffer and Czapek (1894) have finally established the correctness of Darwin's conclusion. It is interesting to recall that Erasmus Darwin had suggested the possible existence of a brain in plants in his 'Phytologia' (1800). But the word 'brain' is misleading, inasmuch as it might imply sensation and consciousness: it would be more accurate to speak of centers of ganglionic activity. However, the fact remains that there exist in plants irritable centers which not only receive stimuli but transmit impulses to those parts by which the consequent movement is effected. The transmission of stimuli has been found in the case of *Mimosa pudica* to be due to the propagation of a disturbance of hydrostatic equilibrium along a special tissue; in other cases, where the distance to be traversed is small, it is probably effected by means of that continuity of the protoplasm to which I have already alluded.

Finally, as regards the mechanism of these movements, we find Sénébier and Rudolphi, the earliest writers on the subject in the nineteenth century, asserting, as if against some accepted view, that there is no structure in a plant comparable with the muscle of an animal. Rudolphi (1807) suggested, as an alternative, that the position of a mobile leaf is determined by the 'turgor vitalis' of the pulvinus, and thus anticipated the modern theory of the mechanism. But he gives no explanation of what he means by 'turgor'; and the term is frequently used by writers in the first half of the century in the same vague way. Some progress was made in consequence of the discovery of osmosis by Dutrochet (1828), and more especially by his observation (1837) that the movements of *Mimosa* are dependent on the presence of oxygen, and are therefore vital. But it was not, and could not be, until the existence of living protoplasm in the cells of plants was realized, and the movements of free-swimming organisms and naked reproductive cells had become more familiar, that the true nature of the mechanism began to be understood; and then we find Cohn saying, as long ago as 1860, that 'the living protoplasmic substance is the essentially contractile portion of the cell.' This statement may, perhaps, seem to put the case too bluntly and savor too much of animal analogy; but the study of the conditions of turgidity has shown more and more clearly that the protoplasm is the predominant factor. The protoplasm of plant-cells is undoubtedly capable of rapid molecular changes, which alter its physical properties, more particularly its permeability to the cell-sap. It may be that these changes cannot be directly compared with those going on in animal muscle; but if we use the term 'contractility' in its wider sense, as indicating a general property of which muscular contraction is a special case, then Cohn's statement is fully justified. This is borne out by the observations of Sir J. Burdon-Sanderson (1882–88) on the electrical changes taking place in the stimulated leaf of *Dionæa*, and by Kunkel's (1878) corresponding observations on *Mimosa publica*: in both cases the electri-

cal changes were found to be essentially the same as those observable on the stimulation of muscle. We find, then, that the advances in Physiology, like those in Anatomy, teach the essential unity of life in all living things, whether we call them animals or plants.

With this in our minds we may go on to consider in conclusion, and very briefly, that department of physiological study which is known as the Bionomics or Œcology of plants. In the earlier part of the century this subject was studied more especially with regard to the distribution of plants, and their relation to soil and climate; but since the publication of the 'Origin of Species' the purview has been greatly extended. It then became necessary to study the relation of plants, not only to inorganic conditions, but to each other and to animals; in a word, to study all the adaptations of the plant with reference to the struggle for existence. The result has been the accumulation of a vast amount of most interesting information. For instance, we are now fairly well acquainted with the adaptations of water-plants (hydrophytes) on the one hand and of desert-plants (xerophytes) on the other; with the adaptations of shade-plants and of those growing in full sun, especially as regards the protection of the chlorophyll. We have learned a great deal as to the relations of plants to each other, such as the peculiarities of parasites, epiphytes, and climbing plants, and as to those singular symbioses (Mycorhiza) of the higher plants with Fungi which have been found to be characteristic of saprophytes. Then, again, as to the relations between plants and animals: the adaptation of flowers to attract the visits of insects, first discovered by Sprengel (1793), has been widely studied; the protection of the plant against the attacks of animals, by means of thorns and spines on the surface, as also by the formation in its tissues of poisonous or distasteful substances, and even by the hiring of an army of mercenaries in the form of ants, has been elucidated; and finally those cases in which the plant turns the tables upon the animal, and captures and digests him, are now fully understood.

CONCLUSION.

Imperfect as is the sketch which I have now completed, it will, I think, suffice to show how remarkable has been the progress of the science during the nineteenth century, more particularly the latter part of it, and how multifarious are the directions in which it has developed. In fact Botany can no longer be regarded as a single science: it has grown and branched into a congeries of sciences. And as we botanists regard with complacency the flourishing condition of the science whose servants we are, let us not forget, on the one hand, to do honor to those whose life work it was to make the way straight for us, and whose conquests have become our peaceful possession; nor, on the other, that it lies with us so to carry on the good work that when this Section meets a hundred years hence it may be found that the achievements of the twentieth century do not lag behind those of the nineteenth.

S. H. VINES.

---

*THE METHOD OF TYPES IN BOTANICAL NOMENCLATURE.**

FOR many decades the systematic botany of the United States can scarcely be said to have had a history separate from that of Europe, so extensively were our treasures exploited by transient visitors, while resident students of the science long remained

* Read at the New York meeting of the Botanical Club of the A. A. A. S., through the kindness of Mr. Charles Louis Pollard. On motion the paper was referred to the Committee on Nomenclature and the author was requested to offer it for publication in SCIENCE.

dependent upon European patrons and correspondents. But even after a considerable independent development had been reached in this country, botany remained centralized to the extent that the writings of a very few masters constituted a large percentage of the published output of the science, and scarcely less in America than in England was the taxonomic side dominated by the spirit and methods of the brilliant coterie of Kew systematists. It was inevitable, however, with the spread of scientific knowledge and the quickening of interest in biological subjects, that the time should come when systematic activity could be confined no longer to a few herbaria, when botany like other sciences must be decentralized. Though this fact has been deplored, especially by those who had enjoyed a more or less complete monopoly of opportunity, it must be admitted that scientific study is one of the natural rights of man about which no artificial barriers can be maintained. Moreover, systematic botany reached a stage when it became evident that the last word could not be spoken from the herbarium, and that the results of local field study are legitimate subjects for record and publication. As long as a few men contented themselves with the issue of a few large treatises per decade, inequalities in their taxonomic views or methods of nomenclature caused comparatively little difficulty, each generation following without serious confusion the recognized authority of its time. But as workers multiplied, the annoyances of contemporary differences became so great that the desire for uniformity gradually crystallized into a movement for the formulation of a rational code of nomenclature by which all might be guided.

As often happens in reform movements, a single issue became prominent, and attention was chiefly directed to the correction of what had come to be regarded as a flagrant and unreasonable abuse of the power of arbitrary change of names. The proposition known as the 'Kew Rule,' to the effect that a species might be renamed whenever transferred to another genus was emphatically negatived in the interest of a consistent application of the principle of priority. This does not mean that such a rule was essentially illogical, any more than was the other custom of eighteenth century botanists who set aside by wholesale the genera of their predecessors, substituting their own improved concepts and more euphonious names. Neither was the changing of specific names anything new; it had been customary throughout the history of systematic botany, but the time had passed when the scientific public could be trifled with, even by the specialist sure of the finality of his own conclusions.

In spite of minor features which still seem objectionable to many botanists, such as the supplanting of specific names by varietal, and the use of duplicate binomials, the 'Rochester Rules' have proved to be a most valuable piece of progressive legislation, the general wisdom and logical authority of which it is not necessary to question. At the same time it is unfortunate that many seem to have expected the new code to be final and perfect, even in matters which did not come before the minds of those who prepared it, but a disappointment in this regard should be no real hindrance to the consideration of other possible improvements in nomenclatorial procedure. Such finality of creeds is scarcely to be expected in progessive sciences, notwithstanding the eminent desirability of permanence and uniformity. The Rochester Code affirms the supremacy of the principle of priority and provides for its universal application in the nomenclature of species. The successful initiation and satisfactory progress of this measure but makes plainer the need of a similarly

salutary regulation for determining the application and precedence of generic names. Although sometimes believed to have been adequately dealt with, this question was only indirectly touched upon by the Rochester Rules, which simply re-enacted by implication the generally neglected provisions of the Paris Code of 1867. This legislation can no longer be considered authoritative, since it was based on the pre-Darwinian doctrine that species are special creations and that the categories of classification are mere mental concepts, instead of groups of individuals having a common origin and phylogenetic relationships. As a concept, there is no particular reason why a genus should not be emended, subdivided or set aside entirely if found erroneous, but as a group of related species for which a permanent common name is desired, the genus should no longer be treated by the formal or conceptual method. Obviously, it is far more important, as well as more scientific and more practical, that a part of organized nature have a fixed designation than that naturalists continue to waste their energy in investigating the applicability and adjusting the claims of the varied succession of rival concepts. Although to many the genus appears to be less tangible than the species, it is possible to guarantee to it the permanence and stability now enjoyed by the species under the Rochester Code. By considering a single species the nomenclatorial type of its genus, to which the name is to remain inseparably attached, we place upon firm ground and solidify to the point of general tangibility and comprehension the misty fabric of conceptual classification.

At the Springfield meeting of the Botanical Club where the legislation begun at Rochester was concluded by the acceptance of the report of the Nomenclature Committee, an attempt was made to secure attention for this matter of definite priority for genera by the recognition of a method of fixing the types. The necessity of some such procedure in carrying out a satisfactory revision of at least one group of organisms was explained in a paper entitled 'Personal Nomenclature in the Myxomycetes.'*

It appeared, however, that those who had been most zealous for the reform of specific nomenclature had not the same appreciation of the problems of generic taxonomy, perhaps because the illogical and unstable results of the method of concepts are less obvious in dealing with the higher plants, and especially with the European and North American floras in which the species of the older writers are nearly always identifiable, at least to the extent of determining their generic relationships. It is thus usually *possible* to apply the so-called method of residues or elimination under which the type species or a genus are held to be those of the original complement which have not been removed. But by this rule it is often quite impossible to fix the application of a generic name to one group of species when several were enumerated under the generic name at its first appearance. Thus if the three original species of a genus are found to belong to as many natural groups the decision as to which shall have the use of the name often depends, in final analysis, not upon anything which can be learned by consulting the original or subsequent descriptions, or even the type specimens, but

*Subsequently published in the *Bulletin of the Torrey Botanical Club*, Oct. 1895, xxii, 431–434. The present and related questions of taxonomy have also been discussed under these titles: 'Stability in Generic Nomenclature,' SCIENCE, Aug. 12, 1898, viii, 186–190, 'The Method of Types,' SCIENCE, Oct. 14, 1898, viii, 513–516, and 'Four Categories of Species,' *American Naturalist*, April, 1899, xxxiii, 287–297. In his 'Review of the Genera of Ferns proposed prior to 1832,' *Memoirs of the Torrey Botanical Club*, Dec. 1899, vi, 247–283, Professor Underwood has restated and applied the method of types, with exceptions required by the present limitations of the Rochester Rules.

upon the present monographer's views as to the relationship of the species with others included under other concepts named by writers previous or subsequent to the date of the genus under investigation. Thus, to take a very simple case, if there were a genus *A* described in 1830 with three species of which *a* is nearest related to *d*, of genus *B*, 1840, *b* is nearest related to *e*, of genus *C*, 1820, while *c* is nearest related to *f*, of genus *D*, 1850, we have already under the method of elimination a series of varying alternatives:

1. If the genera *B* and *C* be deemed valid, *D* cannot be separated, but is considered synonymous with *A*.

2. The systematist who decides that *B* is invalid applies *A* to *a* and *d* and may recognize *D* as a good genus.

3. If *C* be treated as invalid *A* may be applied to *b* and *e*, *B* and *D* being considered good.

Thus while it may be theoretically possible for a monographer to arrange to his own satisfaction the relations of the different genera, a change of taxonomic opinion affects not only the supposed limits of the genera but may *necessitate* a totally different application of the name *A* to any one of the three groups of species. And when we reflect that the complications are increased in almost geometrical ratio when the species are more numerous and when the question of the validity of *B*, *C* or *D* may be subject to equally great complications from other aspects of their real or supposed relationships, it becomes evident that the conceptual method of elimination involves an endless chain of casuistry, and is a counsel of darkness and confusion rather than of stability and perspicacity. Moreover, in the lower plants and animals the large composite genera of the earlier writers are in many cases now distributed, not merely to different families, but even to different orders and classes, so that the elucidation of some of the more difficult cases of residual taxonomy would require months of unprofitable labor in different parts of the biological field, and yet the conclusions could have only individual sanction, no steps in the process being secure with the exception of those which deal with genera described as monotypic. The designation of type species by a simple and uniform method would, however, render the application of all generic names equally definite, and would largely eliminate the personal equations which have thus far added immeasurably to the labor of biologic taxonomy, and which continue to hamper all efforts to popularize the science.

Although, as previously noted, the Rochester Rules gave a tacit adherence to the method of elimination, the case is not, in reality, that of supplanting one method of procedure by another, since with the possible exception of a small proportion of the flowering plants the method of elimination has never been consistently applied in any part of the botanical series. Most botanists, Continental, English and American, have continued to deal with genera in a manner purely personal and arbitrary. Seldom has there been any formal recognition of a type much less the choice of one by any fixed rule. Genera have often been deprived of all their original species and made to do duty for an entirely new set, with or without modification of the original description.

The conditions obtaining in the earlier genera of ferns have been investigated by Professor Underwood, and found to be much the same as in the Myxomycetes and Fungi, while a brief excursion among the palms reveals the persistence there of the spirit of lawlessness. The genus *Oreodoxa*, for example, was based on two species, one of which is now placed in *Euterpe*, and the other in *Catoblastus*, while the name *Oreodoxa* has been applied without warrant to the

royal palm and its allies, which have never been designated by a correct generic name,* whether the difficulty be adjusted by the method of elimination or by the method of types. Of course it is not necessary that the types of phanerogams should be fixed by the same method as in the other groups, but all phanerogamists are not likely to remain contented with an illogical and faulty method, and it is scarcely to be expected that the Committee on Types appointed at the Buffalo meeting, will bring in recommendations for a variety of usage in a matter of so much importance.

In the incorporation of the desired legislation into the Rochester Code a large variety of courses might be followed, but for present purposes it may be sufficient to point out that these lie between two general policies, either of which may be developed in such form as to be both logical and practical. If we adhere strictly to the binomial system, to 1753, and to the '*Species Plantarum*,' we must reconcile ourselves to the misapplication of the pre-Linnæan names or treat them as exceptions and provide for the assignment of types by a committee or a congress, thus disposing at once of many bibliographic complications. This would be in accordance with the argument advanced by some of the advocates of the Rochester Code, that the process of revision of cryptogamic as well as of phanerogamic genera would be greatly simplified by relief from the incubus of the pre-Linnæan and non-binomial literature, an expectation which undoubtedly influenced many in favor of that legislation. It transpired, however, that instead of adhering to the logical consequences of the adoption of a nomenclature of genera and species based on the binomial system with the '*Species Plantarum*' as a starting point, the very committee which had framed the rules fell into the practice of interpreting Linnæus through the works of his predecessors instead of establishing the usage and identifications of his followers, thus rendering the date 1753 merely an arbitrary limit for citations, and virtually abandoning all the advantages which might have been secured by a consistent adherence to the original import of the Rochester Code, as far as it affected the taxonomy of genera. Moreover, in addition to the re-introduction of this complication, there was unearthed a large body of irrelevant, non-binomial literature issued subsequent to 1753, much of which had rested in merited oblivion for upward of a century. To accept as taxonomic literature such writings as those of Adanson, while refusing to cite Tournefort and Micheli, destroys every rational or practical effect of the intended reform and reduces the result of the Rochester legislation, as far as genera are concerned, to the empty absurdity of requiring the false citation of Linnæus and Adanson as the authors of genera which they knew only as compilers from the works of older and better botanists.

It is plain, therefore, that any argument which might have been drawn from the fact of previous legislation, if it had been logically carried out in this respect, has been lost by the apparently unconscious surrender of the Rochester Code reformers to Professor Greene's contention for the recognition of the pre-Linnæan authors, and we may thus without prejudice consider the second of the available alternatives for the enactment of a law for fixing generic names by types. To abandon 1753 as the initial date for generic nomenclature is but frankly to admit what is already an accomplished fact, and to cease to quote Linnæus, Adanson and others as the authors

* A new genus *Roystonea* is proposed, differing from *Oreodoxa* in the solitary growth, the double spathe and other characters. The type is *R. regia* (HBK), Nov. Gen. et Sp. 1 : 305, originally described from Cuba.

of genera which they did not discover. Such a step need not, however, compel us to return to the Middle Ages or to Classical Antiquity; Tournefort's '*Institutiones*' published at the appropriate date 1700 was an important integration of previous knowledge, and has long been considered the beginning of modern botanical literature; beyond this our taxonomy scarcely needs go to. Commencing with the 'Father of Genera' the selection of the first species as the type would result in no complications by reason of the Linnæan arrangement of species, and it may be confidently expected that the uniform application of such a rule would necessitate far fewer changes than would the method of elimination, whereby the doubtful or unidentifiable species are often the only residue on which time-honored names could be maintained.

To many who have desired to minimize as far as possible the bibliographic labor which is so great a burden to systematic botany, the adoption of such a change will be a matter of regret, but this argument cannot be used by the authors of the 'Check List' and other publications prepared on the basis of the Rochester Rules, since these have cheerfully assumed the burdens and multiplied the changes which a closer adherence to the binomial system would have avoided. And yet the task is quite finite, especially since we should be under no obligation to attempt the re-identification of the pre-Linnæan species, but may infer most of them with historical warrant from the citations of '*Species Plantarum*' and subsequent binomial literature.

Choice lies thus between the restriction of taxonomic recognition to genera provided with a binomial species in '*Species Plantarum*' or some subsequent work, or the admission of the genera of Tournefort and his successors whenever referable to an identifiable species, whether binomial or not. While it is true that these alternatives could be combined or modified in a variety of ways, such compromises could result only in exceptions and complications which experience has shown to be held in small favor by those who do not oppose change merely from motives of inertia.

A justification for a *laissez faire* policy in nomenclature is often based on the allegation that since the species and other categories of classification cannot be accurately defined and equalized there is no possibility of the attainment of either uniformity or stability in the use of names. Whatever may have been the justice or the logical propriety of this destructive criticism as applied to a taxonomic system based on the method of concepts, it is purely specious and ineffective with reference to the method of types. The species is a group of individuals, the genus a group of species, the family a group of genera, and these terms are quite as definite and comprehensible as other collective nouns. Botanists may never agree on the number of species, or on the number of groups of species which should be recognized as genera, but it is entirely possible for them to agree on the names as far as they agree on the groups, not by deferring to arbitrary authority, but by adherence to a rational and uniform course of procedure. As long as a genus is viewed as a concept, it belongs, obviously, where it fits best, and it is quite logical to reject it if no correspondence in nature be found, or to move it along to new series of species, where the description is more applicable than to those for which it was drawn. The conceptual theory of taxonomy comported entirely with the doctrine of special creation, but it is not adapted to the purposes of phylogenetic classification as an integration of the results of the study of the evolution of organic types, and its continued use is now unscientific as well as unpractical. As the genus does not consist

of a concept, neither can it become adequately known to us through the medium of description. Botany without designation of types is like geography without position.

In biology a species is a coherent or continuous group of organisms. In such a group the individual organisms have a common origin and may be arranged in connected series of imperceptible gradations with reference to any one character, except in cases of sexual differentiation and alternation of generations, where the coherence of specific groups is maintained by facts of life-history. A species is not constituted by any antecedent determination of the amount of difference it must present; it subsists in virtue of the fact that it has diverged and become disconnected in nature from other groups of organisms, however similar these may be.

For nomenclatorial purposes a species is a group of individuals which has been designated by a scientific (preferably a Latin adjective) name, the first individual to which the name was applied constituting the type of the species. The importance of preserving type specimens with special care is now recognized throughout the scientific world, and where specific types are lacking, naturalists are endeavoring to supply their place by specimens collected in the original localities. This may be taken as a general admission of the obvious fact that purely descriptive methods are generally insufficient for scientific accuracy and need to be supplemented by actual specimens if correct identifications are to be permanently assured.

For purposes of reference and citation specific names which appeared previous to the 'Species Plantarum' of Linnæus are not regarded in botanical nomenclature. In reality Linnæus revived rather than originated the binomial system of nomenclature, but his works embody the results of the first extensive and fairly consistent attempt at the scientific application of the nomenclatorial practice now universally followed.

The method of types applied to genera involves a similar readjustment of views. Under the analytic method of concepts a genus has been defined as a sub-division of a family, but the method of types is synthetic and places the emphasis on the connection with nature by building the genus up from below.

A genus of organisms is a species without close affinities, or a group of mutually related species. Here again the natural arrangement must have reference to the gaps in nature rather than to the logical balance of formal characters.

A generic name is established in taxonomy when it has been applied to a recognizable species. Unless the discoverer of the genus designates a type species in the same publication in which he bestows the name, the first species referred to the genus should serve as its nomenclatorial type.

The generic taxonomy of plants may be treated as beginning with Tournefort's 'Institutiones' (1700).

O. F. COOK.

WASHINGTON, D. C.

SCIENTIFIC BOOKS.

Memoirs presented to the Cambridge Philosophical Society on the occasion of the jubilee of SIR GEORGE GABRIEL STOKES, Bart., Hon. LL.D., Hon. Sc.D., Lucasian Professor. Cambridge, at the University Press, 1900; New York, The Macmillan Co. 4to. Pp. xxviii + 447, with 25 plates. Price, $6.50.

The celebration of the fiftieth anniversary of the Lucasian professorship of Sir George Gabriel Stokes at the University of Cambridge, on June 1 and 2, 1899, brought together a large number of distinguished naturalists, if one may use this convenient term to include astronomers, chemists, geodesists, geologists, mathematicians, physicians, physicists and zoologists. It was one of those occasions which illustrate the essential unity of science by a spontaneous tribute of homage to an eminent specialist from workers in widely divergent fields. During the week following the

celebration the Cambridge Philosophical Society held a special memorial meeting at which a number of mathematico-physical memoirs were presented. These now appear in print for the first time in the volume whose title-page is quoted above. A note on the page following the title-page states that "These Memoirs are also issued as Volume XVIII. of the *Transactions* of the Cambridge Philosophical Society." The book contains also the 'Order of Proceedings at the formal celebration by the University of Cambridge of the Jubilee of Sir George Gabriel Stokes, Bart., Lucasian Professor, 1849–1899'; and 'The Rede Lecture: *La théorie des ondes lumineuses: son influence sur la physique moderne*,' delivered by Professor Alfred Cornu on June 1, 1899. An excellent portrait of Sir George appears as a frontispiece, and the volume is supplemented by twenty-five plates illustrating the different memoirs and by an index.

The semi-popular lecture by Professor Cornu, in addition to giving an admirable summary of the century's progress in physical optics, presents the conclusions of a special study of the work of Newton in this field. To the general reader as well as to the specialist this eloquent address cannot fail to prove interesting and instructive; and the scientific world must applaud the sentiment expressed in the author's closing words:

"Que l'Université de Cambridge soit fière de sa chaire Lucasienne de Physique mathématique, car, depuis Sir Isaac Newton jusqu'à Sir George Stokes, elle contribue pour une part glorieuse aux progrès de la Philosophie naturelle."

The memoirs proper of the volume are twenty-two in number and by as many different authors. They appertain to a wide variety of subjects and are in general strictly technical in character. They are appropriately not too prolix, however; the briefest occupying only 3 and the longest only 56 pages. Pure and applied mathematics are about equally represented, though some of the papers are a little difficult to classify. The titles and authors of the memoirs are as follows:

I. 'On the analytical representation of a uniform branch of a monogenic function,' by G. Mittag-Leffler.

II. 'Application of the partition analysis to the study of the properties of any system of consecutive integers,' by Major P. A. MacMahon.

III. 'On the integrals of systems of differential equations,' by A. R. Forsyth.

IV. 'Ueber die Bedeutung der Constante b des van der Waals'schen Gesetzes,' von L. Boltzmann und Dr. Mache, in Wien.

V. 'On the solution of a pair of simultaneous differential equations which occur in the lunar theory,' by Ernest W. Brown.

VI. 'The periodogram of magnetic declination as obtained from the records of the Greenwich Observatory during the years 1871–1895 (Plates I. II.),' by Arthur Schuster.

VII. 'Experiments on the oscillatory discharge of an air condenser, with a determination of 'v',' by Oliver J. Lodge and R. T. Glazebrook.

VIII. 'The geometry of Kepler and Newton,' by Dr. C. Taylor.

IX. 'Sur les groupes continus,' par H. Poincaré.

X. 'Contact transformations and optics,' by E. O. Lovett.

XI. 'On a class of groups of finite order,' by W. Burnside.

XII. 'On Green's function for a circular disc, with applications to electrostatic problems,' by E. W. Hobson.

XIII. 'Demonstration of Green's formula for electric density near the vertex of a right cone,' by H. M. Macdonald.

XIV. 'On the effects of dilution, temperature and other circumstances on the absorption spectra of solution of dydimium and erbium salts' (Plates III.–XXIII.), by G. D. Liveing.

XV. 'The Echelon Spectroscope,' by A. A. Michelson.

XVI. 'On minimal surfaces,' by H. W. Richmond.

XVII. 'On quartic surfaces which admit of integrals of the first kind of total differentials,' by Arthur Berry.

XVIII. 'An electromagnetic illustration of the theory of selective absorption of light by a gas,' by Horace Lamb.

XIX. 'The propagation of waves of elastic displacement along a helical wire,' by A. E. H. Love.

XX. 'On the construction of a model showing the 27 lines on a cubic surface,' by H. M. Taylor. (Plates XXIV., XXV.)

XXI. 'On the dynamics of a system of electrons or ions: and on the influence of a magnetic field on optical phenomena,' by J. Larmor.

XXII. 'On the theory of functions of several complex variables,' by H. F. Baker.

The pure mathematician will find much of interest especially in Nos. I.–III., VIII.–XI., XVI., XVII., XX., and XXII. of these papers; while the mathematical physicist can hardly fail to discover something instructive in his lines. Together they fitly commemorate the jubilee of one who has rendered signal service in the development of both branches of mathematical science.

Scientific Papers. By PETER GUTHRIE TAIT, M.A., Sec. R. S. E., Honorary Fellow of Peterhouse, Cambridge, Professor of Natural Philosophy in the University of Edinburgh. Vol. II. Cambridge, at the University Press, 1900; New York, The Macmillan Company. 4to. Pp. 1–500. Price, $6.50.

Papers on Mechanical and Physical Subjects. By OSBORNE REYNOLDS, F.R.S., Mem. Inst. C. E., LL.D., Professor of Engineering in the Owens College and Honorary Fellow of Queens College, Cambridge. Reprinted from various transactions and journals. Vol. I., 1869–1882. Cambridge, at the University Press, 1900; New York, the Macmillan Company. Royal 8vo. Pp. xv + 416. Price, $5.00.

In these days of open and easy avenues to publication, when the papers of a fertile author are almost certain to be widely scattered in transactions and periodicals, it is a good sign to see authors and publishers alike willing to undertake the labor and expense of republication in collected form. Especially welcome—perhaps one should say essential—are such collected works to the student of the present and coming generation, for the task of finding out what has already been done in a science is generally one of the most formidable preliminaries to progress.

In the republication of the well-known scientific papers of Lord Kelvin, Sir George Gabriel Stokes and George Green, and in the more recently collected papers of Maxwell, Cayley, Adams, Lord Rayleigh and others, the University of Cambridge has set an example in the work of 'University extension' of which the academic world may well take note. Probably no more effective method of advancing knowledge could be adopted.

Volume II. of the papers of Professor Tait contains numbers LXI. to CXXXIII. They relate to a large variety of topics, ranging from the kinetic theory of gases down through addresses and reviews to notes and brief abstracts. Often, however, these notes and abstracts are full of interest and suggestion, and they serve, as Lord Rayleigh has remarked with reference to his similar republications, 'to relieve the general severity.' Nos. LIX., Report on some of the physical properties of fresh and sea water; LXVIII.–LXXXI., On the kinetic theory of gases; LXXXVIII., On impact; and CXII., On the path of a rotating spherical projectile, are the longer papers of the collection. The last cited paper will be found of special interest to the lovers of golf who may happen to possess the essential but rather rare fondness for mathematical physics. As might be expected, many of the papers refer to quaternions and their applications. Here and there also a biographical notice, like those of Listing, Kirchhoff, Sir William R. Hamilton and Rankine, gives an unexpected interest to the miscellany; and the student of the mathematico-physical sciences is delighted and instructed at every turn of a page. We may not always agree with the author, but we never find him dull.

The papers of Professor Reynolds are reprinted after the same fashion as those of Professor Tait. They are 40 in number and refer to a variety of subjects. Many of them are of great practical interest to the engineering profession; for example, those with reference to the screw propulsion and the steering of ships, the efficiency of belts, the theory of rolling friction, the action of rain and oil in calming the sea, etc. The longest paper, No. 33, is the important experimental and theoretical investigation on certain dimensional properties of matter in the gaseous state, previously pub-

lished in the *Philosophical Transactions*, Part II., 1879. Unlike the volume of papers of Professor Tait, noticed above, this volume of the papers of Professor Reynolds has both a table of contents and an index.

Every one interested in the progress and in the diffusion of science will hope that the 'liberality of the Syndics of the University Press,' under whose auspices these and similar volumes have appeared, will continue to challenge admiration and commendation by the republication of additional collections.

R. S. W.

Kleiner Leitfaden der praktischen Physik. By F. Kohlrausch. Leipzig, B. G. Teubner. 1900.

Even the teachers of physics in America are so familiar with the original 'Leitfaden' that a review of this abridgment may well be essentially a comparison. The term Leitfaden (leading strings) expresses so well what is necesssary in a laboratory that it is to be regretted that we have no English equivalent. As the preface of the smaller book indicates, the larger later editions of the original have become at once a book of instructions and of reference, and has suffered as do all books which grow in that way. The new material is seldom well combined and coordinated with the old. In the new book the author has commenced all over again and distributed the matter consistently.

It is called a *smaller* guide and yet it is necessary to make a detailed comparison in order to discover that some thirty-four paragraphs have been either omitted or considerably condensed and simplified. It is, however, still a very respectable university course in physical laboratory work, and any student who thoroughly masters it will be found well equipped for advanced work. It in no sense can be called an elementary manual. It does not involve mathematics higher than algebra and simple geometry and trigonometry, logarithms and sines, cosines, etc., are assumed. More diagrams and illustrations are used than heretofore and this seems to be a real improvement. A picture book is undesirable, but well chosen diagrams and diagrammatic sketches are a great help to the beginner. This has long been recognized in light and electricity and should be judiciously extended.

Condensation is too often opposed to simplification, but in this case little or nothing of the original clearness seems to be lost in the rearrangement. Nevertheless some good hard thinking and strict attention will be required if the student is to get full benefit.

A chapter on the C. G. S. system of units is placed at the very beginning, and is necessarily very brief, and, although very important, may well be used as matter for reference from time to time as the units arise rather than to be learned at the outset.

Considered from the point of view of the teacher in the general physical laboratory, this book may well supplant the earlier treatise and relegate it to the shelf with other books of reference, and to the advanced special laboratories. It is perhaps well to warn those less familiar with the subject and with German idiom that many words which are identical with the English are used in a different sense; *e. g.*, hydrometer, in English is equivalent of araeometer, but Kohlrausch applies it to the communicating tubes used for densities of liquids. In fact in the chapter on the absolute units it would be essential that a student have the technical English equivalents, and even then some of the German units seem to be superfluous repetitions, and it should be always left clearly impressed upon the mind that 'work,' for example, is always work and always measured in the same unit no matter how the work may be accomplished; and similarly with other units.

The sections on light and especially on electricity and magnetism are very good and complete. The diagrams in the electrical measurements leave nothing to be desired and make one regret that the author did not see fit to illustrate the other subjects with the same liberality and good judgment.

A few useful tables and a good alphabetical index contribute largely to the usefulness of the book, which will be welcomed by every laboratory instructor in physics in college or university.

W. Hallock.

Education in the United States A Series of Monographs prepared for the United States exhibit at the Paris Exposition, 1900. Edited by NICHOLAS MURRAY BUTLER, Professor of Philosophy and Education in Columbia University. Two volumes. Albany, N. Y., J. B. Lyon Co. 1900.

This publication was contributed to the educational exhibit of the United States at the Paris Exposition by the State of New York. Besides a characteristically vigorous, although rather brief 'Introduction' by the editor, the work consists of nineteen monographs as follows: Volume I.: 'Educational Organization and Administration, by President Draper of the University of Illinois; 'Kindergarten Education,' by Miss Susan E. Blow of Cazenovia, New York; 'Elementary Education,' by Hon. Wm. T. Harris, United States Commissioner of Education; 'Secondary Education,' by Professor E. E. Brown of the University of California; 'The American College,' by Professor A. F. West of Princeton University; 'The American University,' by Professor E. D. Perry of Columbia University; 'Education of Women,' by President Thomas of Bryn Mawr College; 'Training of Teachers', by Professor B. A. Hinsdale of the University of Michigan; 'School Architecture and Hygiene,' by Principal Gilbert B. Morrison of Kansas City, Mo.; Volume II.: 'Professional Education,' by James Russell Parsons of the University of the State of New York, Albany, N. Y.; 'Scientific Technical, and Engineering Education,' by President Mendenhall of the Technological Institute, Worcester, Mass.; 'Agricultural Education,' by President Dabney of the University of Tennessee; 'Commercial Education,' by Professor E. J. James of the University of Chicago; 'Art and Industrial Education,' by Mr. I. E. Clarke of the United States Bureau of Education; 'Education of Defectives,' by Principal E. E. Allen of Overbrook, Pa.; 'Summer Schools and University Extension,' by Professor H. B. Adams of Johns Hopkins University; 'Scientific Societies and Associations,' by Professor J. McK. Cattell of Columbia University; 'Education of the Negro,' by Principal Booker T. Washington of Tuskegee, Ala.; 'Education of the Indian,' by Superintendent W. N. Hailman of Dayton, Ohio. There is no summary of the contents or chief propositions of each monograph, as there might well be; but there is a good general index in each of the two volumes. Paper and type are excellent.

Any detailed discussion of such a comprehensive treatise is, of course, out of the question in a brief review like this. One can only touch on some of its most important features, and, incidentally, give a general estimate of the work as a whole.

This collection of monographs is a timely contribution to our educational literature of uncommon interest and value. Our contemporary educational resources and problems have never before been dealt with, in a single treatise, so comprehensively, clearly and tersely. The two volumes, together, comprise less than 1000 pages (973), and yet nearly every phase of our varied provision for education receives attention.

Professor Butler's excellent judgment as an editor is shown both in the general plan of the work and in the selection of the writers of the several monographs. He naturally intended that the work should be a worthy exposition of our whole educational endeavor by persons whose statements of fact could be trusted, and whose conceptions of our educational needs would command respect. In the introduction he tells us "that the present work * * * describes the organization and influence of each type of formal school; it takes note of the more informal and popular organizations for popular education and instruction; it discusses the educational problems raised by the existence of special classes and of special needs, and sets forth how the United States has set about solving these problems. It may truly be said to be a cross-section view of education in the United States in the year 1900."

This description of the scope and purpose of the completed work is, on the whole, just. Such divergences from this description as the work actually presents may be appropriately described, for the most part, as sins of omission. Some important details of the topics considered have received rather scant treatment, and some decidedly important phases of our educational resources and the corresponding problems have not been treated at all.

The best and most interesting portions of the treatise are the monographs of Volume I., and the four monographs of Volume II., on 'Professional Education,' 'Scientific, Technical and Engineering Education,' 'The Education of Defectives,' and 'Scientific Societies and Associations.' The last-named paper is the first appropriate recognition, in print, of extremely important and far-reaching organized influences on our educational activity.

The sins of omission, referred to above are perhaps due to haste in preparation, and to an exaggerated fear of producing too large a treatise. The time for preparation was, doubtless, short, and limitations of size are, of course, necessarily imposed on public documents. Nevertheless, the absence of a monograph on physical training and athletics, or, at least, of a discussion of this topic in connection with school hygiene; the omission of all mention, save incidentally, of evening schools, of which the number and variety are large; the omission of a monograph on the different kinds of our private and endowed schools, some of which, both old and new, are among our most cherished educational resources, and extremely useful in meeting some educational needs not yet adequately met by public schools; the omission of all mention of vacation schools, even if these schools are not yet sufficiently developed to be entitled to a separate monograph;—these omissions from a work exhibiting the educational resources and problems of the United States are to be regretted. So too, it is difficult to see why manual training should not be entitled to a separate monograph as well as commercial education. The writer of the monograph on 'Art and Industrial Education,' necessarily confined himself largely—and, apparently, with no space to spare—to drawing and art; the result is that manual training is nowhere adequately discussed in the entire treatise. No one can doubt that it should be.

Similarly some of the monographs suffer unnecessarily by condensation. In Mr. Draper's paper on 'Organization and Administration' the historical introduction is too brief and fragmentary to possess much value; and there is not, in the paper, even a single illustration of the actual organization and important details of the administration of the school system of an American city. Moreover the whole paper is, with one exception, the shortest in the entire series; and yet the topic with which it deals is second to none in importance. So too, the paper on 'Secondary Education,' which is one of the most valuable and interesting of them all, lacks a very important detail. Mr. Brown justly gives adequate attention to the importance assumed by *electives* in our secondary education; and while he very properly points out that, in some form, electives have long been recognized in our secondary school programs, his monograph does not clearly convey the impression—as it should—that there are many schools throughout the country to-day in which the elective system is dominant. This could have been done easily by inserting two or three typical programs of such schools.

The elective system naturally receives attention again in Mr. West's monograph on 'The American College.' From the general tone of Mr. West's presentation it is not difficult to conclude that he does not favor an elective college course for the B. A. degree. After citing several examples of the different ways in which elective courses for the B. A. degree are administered, Mr. West remarks, "These examples are sufficient to indicate the variety of meaning found in colleges which have changed the historical significance of the Bachelor of Arts degree." No doubt they are. But they convey no impression of the richer and deeper culture for each individual which the B. A. degree represents under an elective system as compared with a prescribed system, in our better colleges, and they do convey the idea that, on the whole, the 'changed historical significance' of the B. A. degree as conferred by these institutions is neither widely accepted nor generally approved; and this, to say the least, is an extremely doubtful assumption.

But it is unnecessary to extend examination to other details of this important series of monographs. In spite of some important omissions and occasional minor defects in detail, the work is, as stated in the beginning of this review, a timely and valuable addition to our educational literature. It will serve to give a

generally sound view of our provision for education to interested foreigners; and to our own students of education in this country, whether superintendents, principals, teachers or university students, it is a store-house of information; at the same time it suggests our many and complex educational problems vividly, and it shows their intimate relation to the other problems of our national life. Its great value to all students of our social and educational problems is indisputable, both as a book of reference and as a foundation for further study.

PAUL H. HANUS.

HARVARD UNIVERSITY.

Catalogue of the Lepidoptera Phalænæ in the British Museum. Vol. II., Arctiidæ (part). By SIR GEORGE F. HAMPSON, Bart.

This volume is similar to Volume I., issued in 1898, and which treated of the family Syntomidæ. It contains the same advantages of practicable keys to genera and species, being simply invaluable to the working entomologist.

The title is misleading, as the work is really a monograph of the groups treated, embracing the known fauna of the entire world, not simply a catalogue of the species represented in the collection of the British Museum, though it may be noted that this collection possesses examples of 77 per cent. of the species described. Each genus and species is described briefly, but characteristically.

The volume contains the subfamilies Nolinæ and Lithosiinæ of the Arctiidæ, as classified by the author. These groups would seem to be more properly of family rank, especially the Nolinæ, which, on larval and pupal characters, show a separate origin from a low Tineid type to that of the Lithosiinæ, which are themselves a true derivative of the Arctiinæ and properly classified here. The larval characters of these groups are, in fact, well marked, though not clearly brought out in the volume before us.

On page 256 we note a curious error, where *Seirarctia bolteri* Edw. is given as a synonym of *Protosia terminalis* Walk., whereas it is really the same as *Halisidota ambigua* Streck., belonging in the Arctiinæ.

There are a number of curious modifications of structure clearly brought out, such as the antennæ of Chamaita, the hind wings of Boenasa and the larva of *Nola argentalis;* but for the details of these we must refer to the book itself.

HARRISON G. DYAR.

DISCUSSION AND CORRESPONDENCE.

THE PSYCHOLOGY OF PITY.

TO THE EDITOR OF SCIENCE: The interesting study of Pity in the July *American Journal of Psychology* suggests some further considerations. In the first place pity as grief *for* another's pain is not sufficiently set off from mere sympathy, *Mitleid*, in the literal sense as partaking of another's pain by direct contagion. All kinds of emotions are contagious, and in the case of fear we denote it by a special name, panic. But it is plain that panic is not pity for fear, but really hinders it; and in general the mere partaking an emotion or feeling interferes so far with emotion for emotion, such as pity. Emotion by contagion adds no new psychic quality, as panic fear is simple fear; but pity is a new specific reaction, and not a mere communication. In contagious painful feeling we seek to suppress the cause; but pity moves us to seek the sufferer, to relieve him not for our own sake, but for his sake. Pity as altruistic grief has thus a quality of its own, as has altruistic joy as distinguished from contagious joy.

Again, this study scarcely notes whether animals pity, and how far pity plays a part in the general struggle of existence as between competitors and as between the hunters and hunted. We judge it likely that the biological origin of pity in its general form is the perversion of parental sympathy in the predaceous animals by the prey as a last resort, the prey thus by cunning circumventing the stronger. The occasional adoption by lions and other ferocious animals in menageries of small beasts offered them as food suggests this, and a closer study of beasts in their natural habitat may show some indications of pity-inspiring as a sub-human method in life and death issues. Certain it is that animals sometimes consciously or unconsciously take advantage of the human

hunter's pity. Thus Carstensen in his 'Two Summers in Greenland' gives an instance of an Eskimo hunter who was so affected by the sad appealing eyes of the seals as he was about to despatch them that he was unable to shoot, and was obliged to give up hunting to the detriment of his own family. Monkeys and giraffes often escape human hunters through the pity their actions inspire when driven to extremity, as all readers of sporting books will recall. Hough reports that even the bear when cornered and completely at the mercy of the hunter sometimes exhibits a pitiful submission and despair.

A third point which deserves more consideration is whether, as the authors represent, the literature of pathos is preferred by mankind in general to that of joy (p. 581). Certainly humorous and comic papers abound, and most news sheets and general periodicals have a section devoted to wit and humor, whereas there are no journals or portions thereof devoted to pathos. Most novel readers prefer, I think, the tale where everything turns out right in the end. The vast vogue of farce and burlesque on the stage is another evidence of popular taste. With the modern development of humor especially with the Anglo-Saxon races, much annoyance and suffering that would once have been pitiable in ourselves and others, is merely laughable. On the whole the present tendency seems to be to restrict the field of pity and to intensify and rationalize it in that field.

The pleasure of pity is little referred to, but the survival theory is mentioned: "It seems as though our race had developed modern civilization in which the leisure field is so vastly widened and the pain field so greatly reduced, too suddenly, and that our nervous system is not yet wonted to so much ease and luxury and had therefore to hark back to play over the old litany of sorrow and pain in the falsetto way of the stage novel and poem." But certainly the primary and main pleasure in pity is that it emphasizes power of protector over protégé, and the secondary source is in seeing the desired relief effected. Pity which is in no wise objective and effective, but solely subjective indulgence—*e. g.*, pleasure in the tragic poem—is like other emotion for its own sake, an art sphere, a late severance of emotion and action, and so while resting upon the past is not to be described as survival, but as the progressive development of experience for its own sake. Thus literature and music idealize pity into pure and subtle forms, and the soul, dissolved in infinite, delicious sadness, experiences the most evanescent and distant development of maternity-paternity.

Hiram M. Stanley.

Lake Forest, Ill., Sept. 10, 1900.

THE KIEFFER PEAR AND THE SAN JOSÉ SCALE.

In his New Jersey Report for 1897 (p. 484), Dr. J. B. Smith writes: "A curious fact was emphasized this year; in an orchard of Kieffer trees, when once it becomes infested [with San José scale], the scales flourish as well as anywhere, and the trees become as completely incrusted as any other variety. But where Kieffer is mixed with other varieties it remains almost exempt, even where neighboring trees are badly infested. This was noticed several times, and Le Conte seems almost less troubled than Kieffer."

In the Yearbook of the Department of Agriculture for 1897 (p. 415), Messrs. Swingle and Webber write: "The Kieffer and Le Conte pears * * * are almost certainly hybrids between the Chinese sand pear (*Pyrus sinensis*) and the common European pear (*P. communis*), since both were grown from seeds of the sand pear obtained from trees which were surrounded by various European pears." On the same page they write of "the problem which the French hybridizers have successfully solved in obtaining hybrid grapes combining the resistance to Phylloxera of the American grape and the quality and size of the fruit of the European grape."

I have elsewhere set forth my reasons for believing that the San José scale is a native of eastern Asia, and, if this is the case, does it not appear that our hybridizers have unwittingly obtained a pear combining resistance to the San José scale with the good qualities of the European pears, the fruit of the Chinese sand pear being very poor? The facts, at all events, are strongly suggestive of such a thing,

and point, perhaps, to the original food-plant of the San José scale.

T. D. A. COCKERELL.

NOTES ON PHYSICS.

ARCHITECTURAL ACOUSTICS.

ABOUT five years ago Professor W. C. Sabine was directed by the Corporation of Harvard University to propose means for remedying the acoustical defects of the lecture room of the Fogg Art Museum at Cambridge. About two years were spent in experimenting on this room and permanent changes were then made.

The experimental work done in connection with this lecture room has led Professor Sabine to take up seriously the general question of architectural acoustics and we are promised a series of papers on this subject the first of which, on reverberation, is published in a recent number of the *American Architect*.

In an introductory chapter Professor Sabine gives a clear and comprehensive statement as to the different ways in which sound is affected by being confined in an audience room, substantially as follows:

The *loudness* of the sound is as a rule greater at a given distance from the speaker than it is in the open air.

The *character* or *timbre* of a complex sound is more or less altered by re-enforcement of certain of its elementary tones by resonance, or by the re-enforcement or weakening of some of its elementary tones at certain parts of the room by interference. This alteration of the character or timbre of a complex sound Professor Sabine calls *ditortiosn*.

The sound *persists* in a room for a considerable time after the sounding body ceases to vibrate. This is due to the more or less complete reflection and re-reflection of the sound from the walls, floor and ceiling. This persistence of sound in a room Professor Sabine calls *reverberation*. It causes the successive sounds in articulate speech to overlap and become confused. Especially the sonorous vowel sounds persist, and obscure the delicate and fleeting variety of the consonant sounds.

The question of loudness becomes a serious matter only in very large audience rooms.

Sound distortion and reverberation depend very largely upon the same conditions. Thus the extent to which an air column will enforce the tone of a tuning fork depends largely upon the length of time the air column will continue to vibrate when left to itself after having been set vibrating. Sound distortion is not so serious a matter as reverberation and, since the two depend largely upon the same conditions, it seems that reverberation only need be considered in any practical case.

The reverberation of a room, measured by the duration of a sound after the sounding body ceases to vibrate, depends upon the absorbing power of the walls and of other reflecting surfaces and upon the size of the room. Thus heavily draped walls or walls lined with thick felt absorb much and reflect little of the sound which strikes them, and a sound persists but a short time in a room of which a considerable portion of walls are padded or draped. An audience also absorbs a large portion of a sound in a room and greatly reduces reverberation. A larger room has greater reverberation than a small room, walls being of similar material, because the sound has farther to travel between succeeding reflections, and a greater time is therefore required for the absorption of a given portion of the sound.

Professor Sabine found that the note of a particular organ pipe remained distinctly audible in the lecture-room of the Fogg Art Museum for 5.6 seconds after the blowing of the pipe ceased. The method proposed and carried out for the reduction of reverberation was to line a considerable portion of the walls of the room with a thick hair felt.

Professor Sabine has determined, by a very ingenious method, the absorbing power of a variety of wall surfaces, such as brick, plaster on brick, plaster on lath, glass and boards, and he has shown that the reverberation of a room can be pre-determined by calculation in terms of the size of the room and the character of its walls.

W. S. F.

NOTES ON INORGANIC CHEMISTRY.

A VERY considerable amount of work is being done at the present time in filling up the many gaps that exist in descriptive inorganic chem-

istry, especially in connection with the rarer elements. The ultimate aim of this work is to determine more accurately the relation of the elements to each other, and incidentally it is doing much to clear up the Periodic Law. Considering the gaps and discrepancies in the work that has been done upon the element *thallium* since its discovery by Crookes in 1861, it is hardly strange that two workers should have selected this for investigation. In the last *American Chemical Journal* a paper by Professor Cushman, of Bryn Mawr, takes up the first chapters of a study of the halogen compounds of thallium; while the last number of the *Zeitschrift für anorganische Chemie* contains a long article by Professor Richard Jos. Meyer, of Berlin, on trivalent thallium, with especial reference to the halogen compounds and the nitrates. There are some very considerable discrepancies between the observations of these two chemists, which will doubtless be cleared up by further study and by comparison. The most important result of Cushman's is the preparation of two isomeric compounds of the formula $Tl_4Cl_3Br_3$, or as they may be written, $TlCl_3 3TlBr$ and $TlBr_3 3TlCl$. Isomerism of this character, while common in organic chemistry, is very rare in inorganic chemistry, and many have asserted that it does not exist. Meyer has added to our knowledge a large series of new thallium salts, and brings out very beautifully the analogies which exist between thallium and gold. As both these authors are continuing their researches, there may be expected decidedly interesting and valuable contributions to our knowledge of thallium in the near future, as each profits by the work of the other.

A NEW and important addition to our knowledge of the chemistry of radium appears in the *Comptes Rendus*, from the pen of Madame Curie. By carefully fractioning many samples of radiferous barium, she has gradually accumulated small quantities of nearly pure radium; indeed, one specimen of a few centigrams was pronounced practically pure and was used for spectroscopic observations. With a specimen of 0.4 gramme concentrated radium, which, however, contained more or less barium, an atomic weight determination was made. This gave an atomic weight of about 174, while the atomic weight of barium is 137.5. This figure of 174 is a minimum, and M. Demarçay considers from spectroscopic observation of the specimen that there was rather more radium in it than barium. In any case it would follow that the atomic weight of radium must be decidedly higher than 174. This would seem to be very strong evidence that radium is an individual element and not a peculiar form of barium.

J. L. H.

ACADEMEI DEI LINCEI OF ROME.

AT the anniversary meeting of the Academei dei Lincei of Rome, Professor Cremona read a biographical notice of Professor Beltrami, who was president of the Academy at the time of his death. The prizes of the Academy announced in the *Atti* are summarized in *Nature* as follows: For the Royal prize of 1000 francs for normal and pathological physiology six candidates entered, and a large number of essays of considerable merit were submitted by them. The prize has been adjudged to Professor Giulio Fano, of Florence, for sixteen papers, dealing, amongst other subjects, with the physiology of the embryonic heart, the doctrine of experimental psychology, the organ of hearing, the graphic registration of respiratory chimism and reflex movements, the latter being a continuation of previous researches on the organs of *Emys Europea*. Of the six candidates for the Royal prize for geology and mineralogy, two were considered worthy of the award, which was therefore divided equally between them. One of the successful candidates, Professor De Lorenzo, chose geological subjects, and sent in about twenty essays, the most important of which dealt with the Trias of the environs of Lagonegro, the Mesozoic mountains of Lagonegro, geological observations on the Apennines of the southern Basilicate and geological studies of the southern Apennines. Professor Giorgio Spezia's work, on the other hand, was entirely mineralogical, dealing with the influences of temperature and pressure, respectively, on the chemical metamorphism of rocks and minerals. From a long and laborious series of experi-

ments, many of them occupying five or six months, the author concluded that pressure has little or no effect, while the influence of temperature is considerable. The results have a special bearing on the theory of quartz formation. The Royal prize for advances in archeological science was adjudged to Dr. Paolo Orsi, of Roveredo, for his investigations of the antiquities of Eastern Sicily. Dr. Orsi has thrown quite a new light on the prehistoric development of the people known as the Siculi, from the neolithic epoch down to the period of expansion of the Greek colonies. A special prize for philosophy and moral science had been offered for an essay dealing with either the theory of consciousness or the foundations of practical philosophy. This prize has been divided equally between Professor Bernardino Varisco and Professor Francesco de Sarlo. The Minister of Public Instruction offered a sum of 3400 lire for two prizes in the physical and chemical sciences, and a like sum for two prizes in the philological sciences, the prizes being confined to teachers in secondary schools. The committee for the prizes in the physical and chemical sciences have awarded two equal prizes—one to Professor O. Marco Corbino, more especially for his work on light traversing metallic vapors in a magnetic field, and the other to be divided between Professors Carlo Bonacini and Ricardo Malagoli, more especially for their joint papers on Röntgen rays. In philology, the prizes have been divided up into a number of minor awards, distributed between Signori Giuseppe Vandelli (whose work stood first), Antonio Belloni, Astorre Pellegrini, Giuseppe Rua, Giuseppe Lisio, Augusto Balsano, Giovanni Negri and Guglielmo Volpi.

THE IMPORTATION OF LIVING ANIMALS.

THE Hon. James Wilson, Secretary of Agriculture, has given notice that under the authority vested in the Secretary of Agriculture by Section 2 of the Act of Congress approved May 25, 1900, entitled 'An Act to enlarge the powers of the Department of Agriculture, prohibit the transportation by interstate commerce of game killed in violation of local laws, and for other purposes,' the list of species of live animals and birds which may be imported into the United States without permits is extended as hereinafter indicated. On and after October 1, 1900, and until further notice, permits will not be required for the following mammals, birds and reptiles, commonly imported for purposes of exhibition: *Mammals*—Anteaters, armadillos, bears, chimpanzees, elephants, hippopotamuses, hyenas, jaguars, kangaroos, leopards, lions, lynxes, manatees, monkeys, ocelots, orang-outangs, panthers, raccoons, rhinoceroses, sea-lions, seals, sloths, tapirs, tigers or wildcats. *Birds*—Swans, wild doves, or wild pigeons of any kind. *Reptiles*—Alligators, lizards, snakes, tortoises or other reptiles. Under the provisions of Section 2 of said Act (as stated in Circular No. 29 of the Biological Survey, issued July 13, 1900), canaries, parrots, and domesticated birds such as chickens, ducks, geese, guinea fowl, peafowl and pigeons are subject to entry without permits. But with the exception of these species and those mentioned above, special permits from the Department of Agriculture will be required for all live animals and birds imported from abroad, and such permits must be presented to the collector of customs at the port of entry prior to delivery of the property.

STREET CARS IN GLASGOW.

THE street car system of Glasgow is owned and operated by the city under the direct supervision of a committee of the town council. The report for the year ended May 31, 1900, as abstracted by our consul, shows that the total length of double track operated by the city is 41 miles. The gross capital expenditures for the system since 1894 (independent of operating expenses) have been $5,164,975, and the present indebtedness is $4,061,806. The capital invested is $4,559,502. Of the 41 miles of double track, five miles have electric traction, the rest being operated by horses. The total receipts of the system during the year were $2,286,850. The working expenses were $1,676,412, leaving a balance of $610,438, of which there was expended some $84,000 for interest on capital, $57,501 for sinking fund, $156,096 for depreciation written

off capital, etc. One item of $60,000 consists of payments made to the general revenue fund of the city, which is in lieu of the amount which the city would receive in taxes, it is presumed, were the system operated by a private company. The balance goes into the reserve fund. There are 3400 persons employed, including 100 clerks. The general manager receives $6800; the chief engineer, $2400; the electrical engineer, $2000; and the mechanical engineer, who has charge of the powerstation, $1216. Point boys receive 28 cents per day; trace boys, from 40 to 52 cents per day; car cleaners, from 88 cents to $1 per day; drivers, conductors, and motormen, from $1 to $1.12 per day. These rates apply to Sundays and week days alike. The rolling stock consists of 384 horse cars, 132 electric cars (47 only of which are now running), 17 omnibuses, 39 lorries, and numerous carts, wagons, and vans. There are 4411 horses. Work is now progressing, with the object of changing the entire system to electric traction, which it is hoped to have completed within the next eighteen months. No underground conduits will be used, according to the present plans. Fares range from 1 cent for first half mile to 2 cents for a mile; the longest ride is 6 miles, costing 6 cents. No transfers are issued and tickets are not used. The committee of the town council having supervision of the tramways receives no compensation. For that matter, however, no member of the city government of Glasgow, inincluding lord provost, town councilors, and bailies (police judges), receives compensation. The city of Glasgow has a population of about 850,000, and spreads over an area of nearly 12,000 acres. There are no electric or other tramways extending out of Glasgow to other towns or cities. Within the city is an underground cable road which makes a circuit of about five miles, and is owned and operated by a private company. The rate of fares on this road is about the same as that prevailing on the surface roads.

SCIENTIFIC NOTES AND NEWS.

Dr. N. L. Britton, director-in-chief of the New York Botanical Garden, has been given leave of absence and is in attendance at the International Congress of Botany in Paris, in which assembly he represents the Garden, and is also an official delegate of the United States. He will visit many of the museums of France and England before he returns. The Board of Managers have designated Dr. D. T. MacDougal as acting director-in-chief of the New York Botanical Garden in Dr. Britton's absence.

Dr. B. T. Galloway, chief of the Division of Vegetable Pathology and Plant Physiology, has been placed in charge of the grounds of the U. S. Department of Agriculture.

Dr. Timbrell Bulstrode, one of the members of the Food Preservatives Committee, and Mr. Charles J. Huddart, the secretary, have, during the past month, visited Amsterdam, Hamburg and various places in Denmark for the purposes of studying the dairying industry and the methods of transport of dairy produce, with special reference to the milk and butter supplies in Holland, Germany and Denmark, and the butter export trade, in relation to the use or non-use of chemical preservatives.

The Duke of Abruzzi has been entertained by the Geographical Society of Christiania, the address of welcome being made by Professor Reusch. He has proceeded to Italy.

The Danish scientific expedition for the exploration of East Greenland, under Lieutenant Amdrup, has reached the shore. The Swedish Kolthoff expedition near Sabine Island found a mast with a Danish flag and a communication from Lieutenant Amdrup to Captain Sverdrup.

Thomas Davidson, well known as an author of philosophical and educational works and as a lecturer, died at Montreal on September 14th, aged sixty years. Mr. Davidson was born in Scotland, but has been living in the United States for the past twenty-five years.

Dr. Lewis Albert Sayre, one of the most eminent surgeons of New York City, died on September 21st in his 81st year. He was one of the founders of Bellevue Medical College and was professor there until the college was united with the New York University two years ago.

There will be a civil service examination on October 23rd and 24th for the position of assist-

ant in the Nautical Almanac office, with a salary of $1000 a year. The examination will be on the mathematical topics required for the computations. On October 23rd there will be an examination for the position of assistant physical geologist in the U. S. Geological Survey at a salary of $600 a year. The examination is chiefly on physics, but French and German are also included. On November 14th, there will be examinations for preparator in vertebrate paleontology and skilled laborer in the U. S. National Museum, with salaries of $900 and $720 respectively. The examinations will be on experience and practical questions regarding the mounting and care of vertebrate fossils. On October 23rd, 24th, and 25th, there will be held the examination we have already noted for the position of chemical geologist in the U. S. Geological Survey with a salary of $1400.

THE Grand Prize of the Paris Exposition has been awarded to the Division of Pomology of the Department of Agriculture, and four gold medals have been awarded to the United States in the horticultural group.

THE Rothamsted Experimental Station established by Sir John Bennet Lawes was some time before his death made over to trustees who hold it for the British nation. In addition to the land and laboratory it has been provided with an endowment of £100,000.

AN elaborate exhibition has recently been held in the Botanical Museum and Conservatories of the Botanical Gardens at Berlin of the plants obtained in South and Central America by Dr. P. Preuss.

AS has already been stated the Nobel prizes will be awarded on the anniversary of the death of the founder, and it is expected that the first award will be made on December 10, 1901.

MAJOR A. ST. HILL GIBBONS has returned from Africa after an absence of two years and three months. We learn from the London *Times* that the expedition covered over 13,000 miles, in addition to travel by railway or steamship routes. The main object of Major Gibbons's journey was to complete the survey of the Barotse country and to determine the tribal distribution there. In this he was successful, and the whole country from the Kafukwe River on the east to the Kwito River on the west and the Zambesi-Congo watershed to 18° south latitude, or a total area of over 200,000 square miles, has been hydrographically and ethnographically surveyed. An interesting feature of Major Gibbons's work in this region was the discovery of the source of the Zambesi at a point nearly 100 miles distant from its supposed position. On the completion of his work in Barotseland Major Gibbons, in order to extend the scope of the expedition, separated from his companions and adopted the northern route, traveling by way of the chain of lakes to the Upper Nile. According to his charts considerable amendments to existing maps will be necessary, both with reference to the relative position, shape and extent of most of the Great Lakes, especially in the case of Lakes Kivu and Albert Edward, the latter of which is now found to be absolutely different in shape and size from the description given in existing maps. By the completion of this journey Major Gibbons has personally travelled a greater distance than any other explorer in Africa, probably not excluding Livingstone. He has never had occasion to use his rifle in anger, and he is proud of the fact that he has never killed a native nor lost one of his boys from death, either by disease or misadventure. He has brought home a large amount of valuable data on the general and political situation of the countries through which he has traveled and over 300 photographs, and his sporting collection includes a white rhinoceros from the Upper Nile.

THE report of the expeditions organized by the British Astronomical Association to observe the total Solar Eclipse of May 28, 1900, will be contained in a volume shortly to be issued from the office of *Knowledge*. The work will be edited by Mr. E. Walter Maunder, F.R.A.S., and will contain many fine photographs of the various stages of the Eclipse.

THE New York *Medical Record* states that a firm of manufacturing chemists in England having applied for a license to perform experiments upon living animals for the purpose of standardizing antitoxins, the Royal College of Physicians was requested to give an opinion as to the

advisability of granting the license. The reply of the College was that, while these experiments were absolutely necessary to the advance of pharmacology, the granting of such licenses to commercial firms was very undesirable. The standardization of antitoxins should be done in a government laboratory into which the question of money-making did not enter.

The results of measurements of various rivers and the observations of height have been published by the U. S. Geological Survey in a series of Water-Supply Papers, Nos. 35 to 39, inclusive, arbitrary division into five parts being necessary by the requirements of law limiting these papers to 100 pages each. They are as follows:

No. 35 (Part I.) rivers flowing into the Atlantic Ocean from Maine to Virginia.

No. 36 (Part II.) rivers flowing into the Atlantic south of Virginia.

No. 37 (Part III.) rivers flowing from the eastern Rocky Mountain area.

No. 38 (Part IV.) rivers tributary to the Colorado, the interior basin, and Columbia River.

No. 39 (Part V.) California streams, and rating tables.

Application for these papers should be made to Members of Congress, by whom 4000 copies of the 5000 printed are distributed, or to the Director of the U. S. Geological Survey, Washington, D. C.

In an article in *Nature* on latitude-variation, earth-magnetism and solar activity Dr. J. Halm summarizes his conclusions as follows: (1) The changes in the motion of the pole of rotation round the pole of figure are in an intimate connection with the variations of the earth-magnetic forces. (2) Inasmuch as the latter phenomena are in a close relation with the state of solar activity, the motion of the pole is also indirectly dependent on the dynamical changes taking place at the sun's surface. (3) The distance between the instantaneous and mean poles decreases with increasing intensity of earth-magnetic disturbance. (4) The length of the period of latitude-variation increases with increasing intensity of earth-magnetic disturbance. (5) In strict analogy with the phenomena of auroræ and of magnetic disturbance, the influence of the eleven-years' period of sun-spots, as well as of the 'great' period, is clearly exhibited in the phenomenon of latitude-variation; and the same deviations from the solar curve as are manifested by the auroræ are also evident in the motion of the pole. (6) The half yearly period of the earth-magnetic phenomena influences the motion of the pole of rotation in such a way that its path, instead of being circular, assumes the form of an ellipse, having the mean pole at its center. (7) The half-yearly period also explains the conspicuous fact of a rotation of the axes of the ellipse in a direction opposite to that of the motion of the pole.

Judge Townsend in the U. S. Circuit Court for the District of Connecticut has handed down a decision sustaining Mr. Tesla's patents for the rotating magnetic field, but the case will doubtless be appealed to the Supreme Court. The learned judge described the progress of electrical knowledge as follows: "The search lights shed by defendant's exhibits upon the history of this art only serve to illumine the inventive conception of Tesla. The Arago rotation taught the schoolboy fifty years ago to make a plaything which embodied the principle that a 'rotating field could be used to rotate an armature.' Baily dreamed of the application of the Arago theory by means of a confessedly impossible construction. Deprez worked out a problem which involved the development of the general theory in providing an indicator for a ship's compass. Siemens failed to disclose the 'suitable modification' whereby his electric light machine might be transferred into a motor, and Bradley is almost equally vague. Eminent electricians united in the view that by reason of reversals of direction and rapidity of alternations an alternating current motor was impracticable, and the future belonged to the commutated continuous current. It remained to the genius of Tesla to capture the unruly, unrestrained and hitherto opposing elements in the field of nature and art and to harness them to draw the machines of man. It was he who first showed how to transform the toy of Arago into an engine of power; the 'laboratory experiment' of Baily into a practically successful motor; the indicator into a driver; he first conceived the

idea that the very impediments of reversal in direction, the contradictions of alternations might be transformed into power producing rotations, a whirling field of force. What others looked upon as only invincible barriers, impassable currents and contradictory forces, he seized, and by harmonizing their directions utilized in practical motors in distant cities the power of Niagara."

PROFESSOR E. RAY LANKESTER communicates to *Nature* a letter from Captain Hind remarking that "It is a curious fact that a bird which is so valuable as Buphaga in clearing parasitic insects from cattle that we lately agreed to give it special protection at the International Conference on the Preservation of African Wild Animals, should now, by a sudden change of conditions induced by man, become a dangerous and noxious creature. This fact shows how difficult is the problem presented by the relations of civilized man to a fauna and flora new to his influence." The letter is as follows: "The common rhinoceros-bird (*Buphaga erythroepyncha*) here formerly fed on ticks and other parasites which infest game and domestic animals; occasionally, if an animal had a sore, the birds would probe the sore to such an extent that it sometimes killed the animal. Since the cattle plague destroyed the immense herds in Ukambani, and nearly all the sheep and goats were eaten during the late famine, the birds, deprived of their food, have become carnivorous and now any domestic animal not constantly watched is killed by them. Perfectly healthy animals have their ears eaten down to the bone, holes torn in their backs and in the femoral regions. Native boys amuse themselves sometimes by shooting the birds on the cattle with arrows, the points of which are passed through a piece of wood or ivory for about half an inch, so if the animal is struck instead of the bird no harm is done. The few thus killed do not seem in any way to affect the numbers of these pests. On my own animals, when a hole has been dug, I put in iodoform powder, and that particular wound is generally avoided by the birds afterwards; but if the birds attack it again, they become almost immediately comatose and can be destroyed. This remedy is expensive and not very effective. Is there any other drug you could suggest that would be less likely to be detected? Perhaps you know that I reported three years ago that these birds rendered isolation under the cattle plague regulations useless in some districts, as I proved beyond doubt they were the only means of communication between clean and infected herds under supervision, a mile or two apart. These birds I have never seen on the great herds of game on the open plains, but I have seen them on antelope and rhinoceros in the immediate neighborhood of Masai villages and herds of cattle; on the other hand, I have never seen the small egret on cattle, though often on rhinoceros and gnū."

THE work done at the Pasteur Institute in Paris, so far as regards the treatment of rabies, is set forth in the last issue of the *Annales de l'Institut*, which is abstracted in the London *Times*. It appears that 1614 persons were inoculated, of whom 1506 were French, 74 English and Indian, 15 Belgian, seven Swiss, four Greeks, three Spanish, two each Dutch and Turks, and one from Morocco. Of the 1614 under treatment, 188 were bitten on the head or face, 965 on the hands and 464 on other parts of the body; while the number of deaths, excluding six which occurred before the treatment was completed, did not exceed four. The full return of the treatment since Pasteur commenced it is as under:

Year.	No. of persons treated.	No. of deaths.	Rate of mortality. per cent.
1886	2671	25	.94
1887	1770	14	.79
1888	1622	9	.55
1889	1830	7	.38
1890	1540	5	.32
1891	1559	4	.25
1892	1790	4	.22
1893	1648	6	.36
1894	1387	7	.50
1895	1520	5	.33
1896	1308	4	.30
1897	1521	6	.39
1898	1465	3	.20
1899	1614	4	.25

It must be pointed out that since the Pasteur Institute was started in Paris several others have been opened in different European countries, so that it is not surprising to find that the

number of persons under treatment has never been so large as it was in the first year.

UNIVERSITY AND EDUCATIONAL NEWS.

Mr. A. C. Bartlett has given the University of Chicago $125,000 for a gymnasium as a memorial of his son who died on July 15th.

A collection of eight hundred Arabic manuscripts, made by Count Landberg and said to be worth $20,000, has been presented to Yale University by Mr. Morris K. Jesup of the American Museum of Natural History.

The trustees of the College of the City of New York are considering the lengthening of the course to seven years. They have asked that the appropriation made by the Board of Estimate and Apportionment last year be increased from $200,000 to $225,000. It is expected that the new buildings in 138th Street will be begun during the present autumn.

The new president of the University of Rochester, Rev. Rush Rhees, who was elected last June, has assumed control, and his formal installation will take place on October 11th. President Seth Low, of Columbia University, will deliver an address on 'The City and the University'; President Harper, of the University of Chicago, will speak on 'The College Officer and the College Student'; President Seelye, of Smith College, will speak on 'Limitations to the President's Power in the American College.'

The London *Educational Times* states that during the coming session evening science courses will be held in connection with the Technical Education Board at University College, King's College and Bedford College. At University College Professor J. A. Fleming, F.R.S., will give a course of ten lectures, followed by laboratory practice, in advanced electrical measurements. A course of lectures on the electric motor and its application to electric traction will be given by Professor C. A. Carus-Wilson, each lecture to be followed by an experimental demonstration or by a class for the practical working of numerical examples in connection with the subject. A course will be given by Professor E. Wilson at King's College on direct and alternating currents. In mechanical engineering, Professor T. Hudson Beare will give a course of ten lectures at University College, on the theory of steam engines and boilers, with laboratory work on the testing of steam engines and boilers. Professor Beare will also give a course of five lectures on the theory of gas and oil engines, combined with laboratory work.

David J. Brewer, Associate Justice of the United States Supreme Court, has accepted the position of lecturer on the responsibilities of citizenship at Yale University. The lectures will be delivered next February.

Professor Goss, who has for a number of years been professor of mechanical engineering and director of the mechanical laboratory in Purdue University, Lafayette, Ind., has been made dean of the Engineering Schools of the University.

Professor L. C. Glen, of South Carolina College, has been appointed professor of geology at Vanderbilt University.

J. R. Street, Ph.D. (Clark), has been appointed professor of pedagogy at Syracuse University.

Mr. Alexander Macphail, M.B., C.M., senior demonstrator of anatomy in Glasgow University, has been appointed professor of anatomy in St. Mungo's College, Glasgow.

The following promotions have been made in German universities: Dr. Wilhelm Authenrieth, of the University of Freiburg, has been appointed associate professor of pharmaceutical chemistry; Dr. R. Abegg, of the University of Breslau, associate professor of chemistry; Dr. A. Loewy, of the University of Berlin, professor of physiology; Dr. Osann, of the University at Bâsle, associate professor of geology and mineralogy; Dr. Paul Eisler and Dr. Vorländer, of the University at Halle, associate professors of anatomy and chemistry, respectively.

Dr. Joseph Anton Gmeiner has qualified as docent in mathematics in the University of Vienna; Dr. Max Schwarzmann, as docent in mineralogy at the University of Giessen; Dr. Joseph Boleslaw Grzybowski, as docent in paleontology at the University of Cracow and Dr. Steinbrück as docent in agriculture at the University at Halle.